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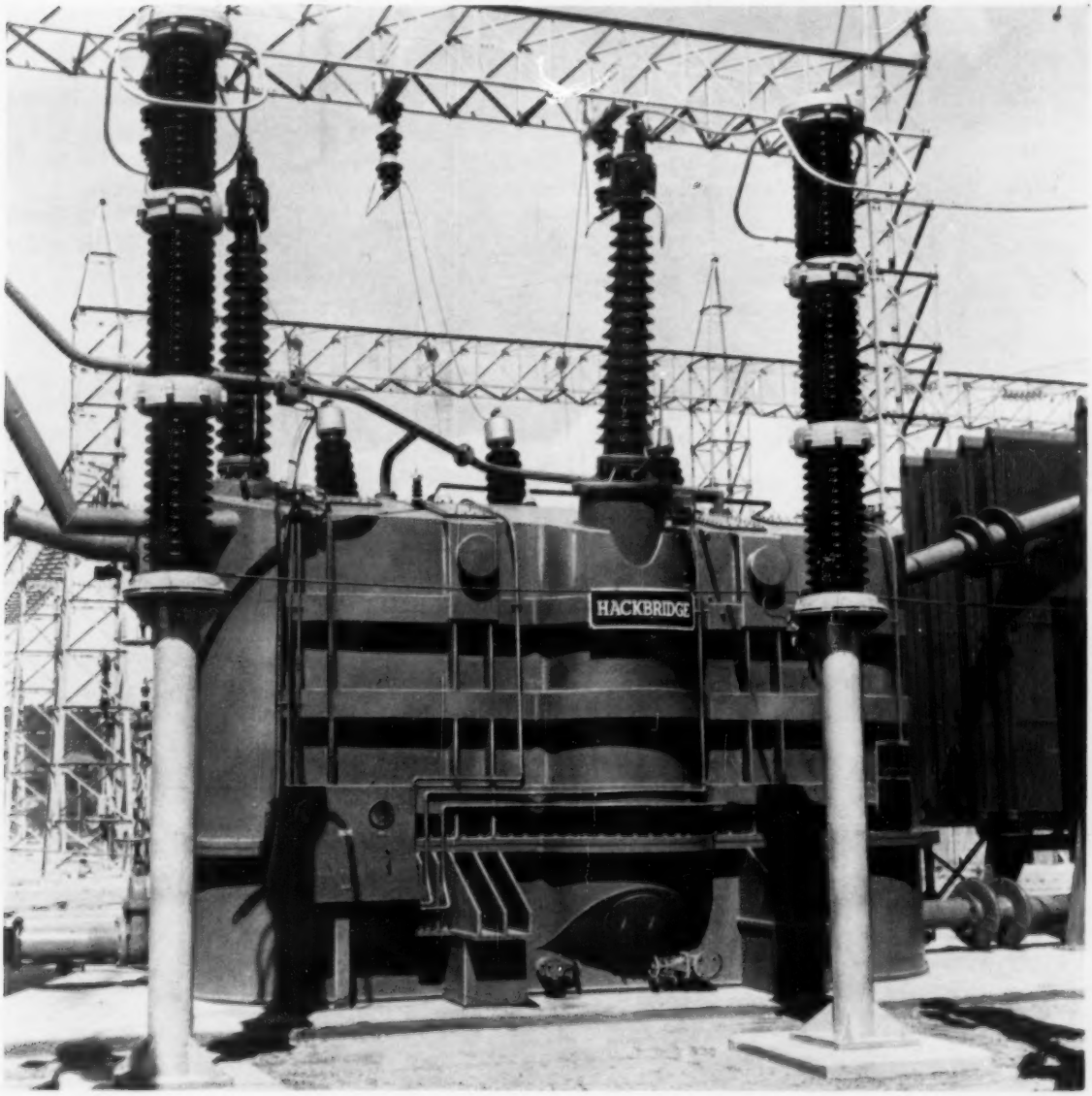


*British Transformers in Tasmania*

A QUARTERLY REVIEW OF
BRITISH ELECTRICAL AND ALLIED ENGINEERING

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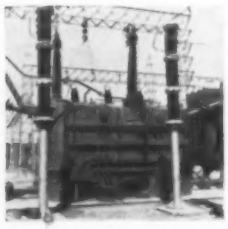

**Cover Illustration.** *One of a bank of three* 100 *MVA* 220/110 *kV 3-phase naturally cooled auto-transformers manufactured by Hackbridge and Hewittic Electric Co Ltd and installed at the Chapel Street Substation, Hobart, of the Tasmania Hydro-Electric Commission*


*Editor:* **John Dyer**

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A QUARTERLY REVIEW OF BRITISH ELECTRICAL AND ALLIED ENGINEERING

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# The Industry Forges Ahead

This issue of THE BEAMA JOURNAL, appearing as it does soon after the publication of the Annual Report of The BEAMA, provides an opportune moment to review the progress of the British electrical and allied industries.

The Annual Report is more than just a record of the work of the Association itself, valuable as this is in assisting the industry in its world-wide trading activities. The BEAMA in its collective sense is virtually the industry, and the 40 or so pages of the Report constitute a wide-ranging survey of the industry's activities and progress which have a direct bearing on the products and services which are available to our customers in all the world's markets.

1960 was not an easy year for British electrical manufacturers. It was marked by an intensification of the changes which have been strongly influencing the development of the industry in recent years. Technical achievements and the increased pace of technological advance are radically affecting the structure of many sectors, such as power generation; changes in Government policy, notably on nuclear power, railway modernisation and consumer goods, have sharply impinged on production programmes; and changing commercial conditions have been accompanied by groupings and amalgamations which have had an effect on the structure of the industry as a whole.

Against this background of change, it is noteworthy that output and employment in the electrical manufacturing industry reached new high levels—in itself a tribute to its enterprise and adaptability. Preliminary figures indicate that a rise of 5 per cent took place in the volume of production during 1960, the value of the output of the whole range of electrical and allied engineering products, including lamps, cables and electronic equipment, amounting to more than £1 600 million. The number of workers in November totalled 795 000—over 30 000 more than in November 1959.

Apart from the consumer goods side, which was severely hit by changes in credit control, nearly all the main sectors of the industry maintained or increased their output. In particular, production of turbo-generating plant reached a new high record; the capacity of plant delivered in 1960 was 5 146 MW, of which plant with a capacity of 1 871 MW (or 36 per cent) was despatched overseas.

On the technical side, advances continue to be made in power generation, resulting in improved thermal efficiency and a reduction in the capital costs per kilowatt of plant. Estimates of the costs of the large 550 MW sets to be installed in 1963 are put at £40 per kW of plant installed—a reduction of 20 per cent on the estimated average of £50 per kW in 1960. The costs of nuclear power plant, although considerably more than the conventional power stations at the present time and still in the comparatively early stages of development, are falling even faster.

At the same time, the thermal efficiency of generating plant is steadily increasing, and the Central Electricity Generating Board reports that the overall thermal efficiency of its power stations during 1960 was 26·71 per cent, compared with 26·36 per cent for the previous year, resulting in a saving of nearly £3 million in fuel costs.

The 20 most efficient stations, which provided nearly one-third of the power supplied by all the stations, had an average efficiency of 31·49 per cent, the individual percentages ranging from 34·28 down to 30·04.

The new sets mentioned above are expected to give efficiencies of the order of 36 per cent, but this will be substantially exceeded by the still newer super-critical sets for which the first contracts were placed last year and for which an efficiency approaching 40 per cent is predicted.

Transmission systems are being designed at new high voltages to achieve greater efficiency and economy. In the field of railway electrification, schemes have been introduced on the new high-voltage a c system employing the most advanced techniques under conditions unparalleled in any other country. Output and exports

of industrial electronic equipment are rising rapidly to match the demand for re-equipment of factories in line with modern processing techniques.

In the field of overseas trading, the industry established a new record level of exports in 1960 amounting to £293 million, representing 10 per cent of the total export of manufactured goods from the U K.

As is to be expected in an industry covering such a wide range of products, there were marked variations in the experience of the different sectors. Exports of domestic electrical appliances were a considerable improvement on the 1959 performance, particularly of home laundry equipment; the exports of washing machines and dryers totalled close on £8·8 million for the year.

Turbine exports also made another notable advance, reaching the record figure of £17·7 million—over 20 per cent more than in 1959. It has to be borne in mind that much of this total is the result of orders placed two or three years earlier, but the results in 1960 reflect great credit on the firms concerned in this highly competitive sector. Exports to North America accounted for at least one-third of the total and included large sets of 200 MW and 300 MW which were delivered during the year. Together with electrical machinery and industrial engineering products, mainly motorised equipment, this heavy engineering side of the industry accounted for about one-third of all electrical exports.

Commonwealth countries continue to be the industry's chief customers, Australia and New Zealand together purchasing more than 13·5 per cent of total exports. South Africa, India, Canada and the United States were also large buyers. Substantial progress was made in Europe, both in the Common Market and E F T A countries, and close on one-quarter of the total electrical and allied exports was made to the Continent.

Behind this story of achievement lie very great efforts in research and development—on which the industry spends an estimated figure of over £64 million a year; in education and training schemes; in national and international standardisation, and many other associated activities in all of which The BEAMA plays an active part.

In 1961, its Golden Jubilee year, the Association is giving absolute priority to practical ways of assisting the industry's overseas trading. The efforts include the production in the autumn of The BEAMA Directory, which will become a valuable work of reference for buyers of electrical products throughout the world.

## Training for Traction

The growth of railway electrification in many countries of the world has inevitably given rise to an increasing demand for electrical engineers with a specialised training in traction.

For nearly half a century, Britain has supplied the equipment and the engineering knowledge for railway electrification systems in every continent of the world; knowledge gained partly in the hard school of experience, but all the more varied and valuable because the experience has embraced such a wide field and so many different systems and requirements.

Today the pace of technological development and the widespread adoption of electrification schemes have increased the demand for specialist engineers. For one thing, the large-scale programme of railway modernisation and electrification in the United Kingdom, and the adoption in this and other countries of the high-voltage a c overhead conductor system, have thrown into sharp relief the difficulty experienced both by the railways and by industry of recruiting a sufficient number of junior engineers with the right background and experience to fill responsible positions.

This situation must be rectified—and quickly—to facilitate the expansion of the electric and diesel-electric railway services in Britain and to provide overseas countries in increasing measure with the highly developed equipment and technical skills which over the years have built up our very considerable export trade.

The BEAMA, in co-operation with the British Transport Commission, has therefore taken the initiative and the two bodies have recently decided jointly to sponsor the formation of a special section at the Imperial College of Science and Technology in London for post-graduate study of electric traction, providing a one-year course suitable for young engineers already holding a degree in electrical engineering and preferably with some industrial experience.

The new section is included within the Department of Electrical Engineering, the head of which—Professor A. Tustin—has previously had considerable industrial experience of electric traction both in this country and abroad. Students successfully completing the course will be awarded the Diploma of the Imperial College (D I C).

It is intended that the work of the section shall be under the direction of a Reader appointed by the University, with the assistance of a lecturer and supported by other electrical staff and the general facilities of the College.

The course was initiated towards the end of last year, and includes five series of lectures covering the whole field of electric traction and supplemented by personal tuition and work in the laboratory. In addition, through the courtesy of British Railways, instruction is given on actual traction equipment, either in the B R electrical laboratory or on the line.

To help in setting up the new section, British Railways have lent the services of Dr H. I. Andrews, Assistant Electric Traction Engineer on their headquarters staff, and he will be assisted by Mr H. P. Grimshaw, a specialist in traction motor design, whose services have been lent by Associated Electrical Industries Ltd.

Applications for enrolment for the one-year course starting in October 1961 and ending in July 1962 can now be accepted. Candidates should hold an honours degree in electrical engineering or its equivalent.

Applications must be sent not later than August 31 next, to the Registrar, Imperial College, London, SW7.

# Fuel Cells

## A REVIEW OF CURRENT PROGRESS

*H. H. Chambers*, PhD, ARCS, DIC, ARIC*

**Introduction**

Fuel cells have received a considerable amount of publicity in the last few years, much of it ill-conceived and some of it quite misleading. The casual reader might well wonder why, if recent reports can be believed, there is not yet a commercial fuel cell on the market. One of the objects of this paper is to review the present achievements and explain the difficulties which must be overcome before the fuel cell can compete seriously with the usual methods of electricity production.

All the current methods of producing electricity from fuel involve burning the fuel to drive a heat engine coupled to a generator. The overall efficiency in terms of the percentage of stored energy in the fuel that is actually converted into electrical energy is rarely more than 30 per cent and usually well under 25 per cent. It is often said that this is because the heat engine is theoretically an inefficient device for converting heat into mechanical work, by virtue of the limitations imposed by the Second Law of Thermodynamics. This is only a half-truth.

It is unfortunate that the word 'efficiency' has come to be used loosely in so many different ways as to confuse the real issue. Logically the word 'efficiency' should be defined in such a way that it expresses the performance of a practical device compared with the calculated performance of a theoretically perfect device operating under the same conditions. On this basis the modern heat engine can be shown to approach closely to the theoretical Carnot engine. The real weakness of conventional power generating processes and the thing which limits the amount of useful energy that can be obtained from a ton of fuel is that the first step in the process, the burning of the fuel, is from a thermodynamic standpoint a highly irreversible process.

When chemical energy is transformed into heat it loses some of its capacity for doing useful work and so it is said to be 'degraded'. The higher the temperature at which the heat is produced the less is the amount of degradation, but of course there are practical difficulties in running heat engines at very high temperatures. It is fair to say that at the present time the upper temperature limit of operation of a heat engine, imposed by purely practical considerations, makes it impossible to convert more than about 40 per cent of the calorific value of the fuel into electrical energy.

If we want to attain a higher overall conversion, then basically our problem is to avoid degrading chemical energy into heat. We must go directly from chemical energy to electrical energy. This is the object of the fuel cell.

* Sondes Place Research Institute

**The Principle of the Fuel Cell**

In principle the fuel cell is no different from any other primary electrochemical cell. You can even regard a dry battery as a fuel cell if you choose to think of the zinc can as the 'fuel', which is oxidised as the battery delivers current.

In a true direct fuel cell, the fuel is fed continuously to one electrode and air continuously to the other. The electrodes are separated by an electrolyte which permits ions to pass from one electrode to the other, but prevents direct contact between fuel and air so that ordinary chemical combustion cannot take place. The fuel can be oxidised only by reacting at the fuel electrode with negatively charged ions containing oxygen which have been formed at the air electrode and have migrated across the electrolyte barrier. During the oxidation process at the fuel electrode the oxygen-containing ions lose electrons to the fuel electrode, which thereby acquires a negative charge. Simultaneously, at the air electrode more oxygen-containing ions form by oxygen taking up electrons from the air electrode and giving it a positive charge. When the cell is on open circuit these processes come to a halt when a voltage of about 1 V has been built up across the cell. If the electrodes are connected by an external wire, however, the electrons discharged at the fuel electrode are able to return through the external circuit to form more negative ions at the air electrode. This process continues as long as the electrodes are kept supplied with air and fuel respectively.

**Converting Energy**

Under these conditions the energy of oxidation of the fuel appears not as heat, but as electrical energy. Inasmuch as there is no degradation of chemical energy to heat, the cell is capable of converting 100 per cent of the available energy in the fuel into electricity. In a practical fuel cell there is always some heat evolved because the cell never has a theoretical performance except at vanishingly small currents. The competitiveness of the fuel cell resides in the fact that it is perfectly feasible to get high power outputs with very much less degradation of chemical energy to heat than is possible with any system running on a thermal cycle. The heat evolution in a fuel cell is purely incidental and is to a large extent avoidable.

The electrodes differ from those of other primary cells in that they are not consumed. They have two

functions: they conduct the current out of the cell and they provide a large area of contact between the gas and the electrolyte, on which the electrode reactions can take place. They have to be catalytically active so that they facilitate the electrochemical reactions between molecules, electrons and ions, without themselves undergoing any chemical change.

The electrodes are commonly made of porous metal or metal oxides so that they expose a large area to the electrolyte and the gas. This introduces a practical difficulty. Unless special precautions are taken there is a danger that the electrodes may become completely flooded with electrolyte, thereby hindering the access of gas. On the other hand, if the gas pressure becomes too high there is a risk of the gases bubbling right through

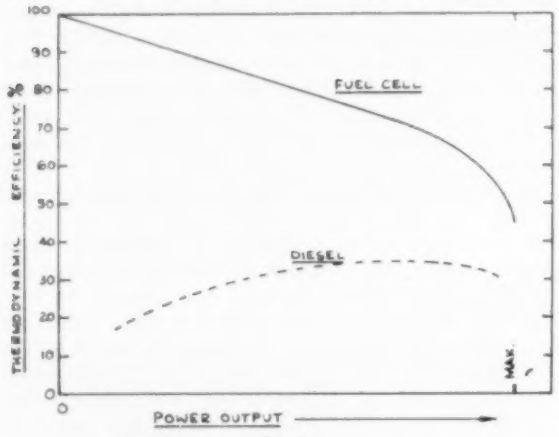



*Fig 1*

*Showing the general relation between thermo-dynamic efficiency and load in a fuel cell*

the electrodes into the electrolyte. Ideally the gas-liquid interface should be somewhere inside the porous electrodes. To ensure that this is so, it is common practice either to waterproof the electrodes or to grade the pore-size of the electrodes in such a way that surface-tension forces keep the interface in the right place.

The choice of electrolyte is rather limited: it must have a high conductivity; it must have negative ions containing oxygen; it must not dissolve either air or fuel nor react with either or with the products of oxidation; and it must not attack the electrodes or other parts of the cell. With these restrictions it is not surprising to find that nearly all the successful cells have used either alkali metal hydroxides or alkali metal carbonates, the former for hydrogen fuel cells and the latter for carbonaceous fuel cells.

The catalytic properties of the electrodes are important, because upon them depends the nature of the fuel the cell will accept and the temperature at which the cell has to be operated. If the catalytic activity is not of a high enough order, the electrode reactions will not keep pace with other processes in the cell at high currents and the terminal voltage will fall on load. Electrochemically active fuels like hydrogen require only moderately catalytically active electrodes, even at low temperatures. Fuels such as hydrocarbons require an extremely high order of activity at low temperature, but in general the higher the temperature the less is the need for high activity.

An ideal fuel cell would run at high efficiency on air and any industrial fuel at room temperature and atmospheric pressure; it would start up instantaneously from cold; it would have power/weight and power/volume ratios at least as good as, say, diesel-generator sets; it would have a long life without maintenance; and it would be cheap to mass-produce. Before we consider the likelihood of such a cell being developed, we must review the present achievements.

**Recent Fuel Cells**

One of the first fairly successful room-temperature cells was developed in the U S A by National Carbon Co. With porous carbon electrodes activated with precious metals and an aqueous caustic potash electrolyte, it runs for long periods on hydrogen and oxygen or hydrogen and air. Its current output is limited to about 50 A/ft$^2$ (540 A/m$^2$) because at higher values the porous electrodes are flooded by the water formed in the cell reaction, in spite of a water-repellancy treatment of the electrodes. The cell will not operate on carbonaceous fuels.

Another interesting American development is the General Electric hydrogen cell with solid ion-exchange membranes instead of the usual liquid electrolytes. This is likely to be expensive to manufacture, but it may well have some special applications. It will not operate on any fuel except hydrogen.

The much-publicised Allis-Chalmers battery is another hydrogen cell. The original claims to operate on propane have now been retracted.

In Germany Prof Justi has obtained impressive results with hydrogen at room temperature using very active Raney nickel electrodes, but again there is no suggestion of successful performance on hydrocarbon fuels. As far as is known the engineering problems of battery design have not yet been tackled.

The most fully engineered cell to date is the Bacon cell, operating at a medium temperature of 200 deg C and 400 lb/in$^2$ (28 kg/cm$^2$) pressure on pure hydrogen and oxygen. This cell will not accept hydrocarbon fuels. Its most likely application is as part of a high-efficiency storage system using pure hydrogen and oxygen produced electrolytically with off-peak power.

**Low Temperature Fuel Cells**

As far as I am aware, nobody has yet demonstrated the possibility of running a fuel cell at low temperature on hydrocarbon or carbonaceous fuels. The main difficulty is that all fuels except hydrogen are electrochemically inactive and at ordinary temperatures they will not undergo rapid reaction with oxygen ions even in the presence of very active catalysts. It is not beyond the bounds of possibility that sufficiently active electrodes will be found ultimately, but there are reasons for believing that even if suitable electrodes are developed, they will be very susceptible to catalyst poisons which are present as impurities in most commercial fuels. Low-temperature fuel cells are likely to require specially purified and expensive fuels and therefore they do not appear to have much future except for very specialised uses.

At higher temperatures electrochemical oxidation of hydrocarbons proceeds rapidly on electrodes with only moderate catalytic activity, that is to say electrodes that are relatively easy to make and are not easily damaged by catalyst poisons. At the present state of our knowledge, if we wish to use ordinary cheap commercial fuels we have to turn to high-temperature cells and accept the practical problems of finding suitable materials of construction to withstand the rather corrosive conditions likely to be met with. At temperatures much above 150 deg C we must also accept that aqueous electrolytes must be replaced by fused salts.

High-temperature cells have been studied in the U S A, Holland, Germany and Great Britain. All the cells have a number of features in common, including the use of fused carbonate electrolytes, and they differ mainly in the nature of the electrodes and the detailed mechanical design. I propose to confine my remarks to our own work at Sondes Place, which I believe has been more closely concerned with hydrocarbon fuels than some of the parallel work abroad, where interest has been focussed on coal gasification products such as carbon monoxide, hydrogen, producer gas, etc.

Our work started in 1953 under a Ministry of Power contract with some support by the Central Electricity Authority (now the Central Electricity Generating Board) and later by Shell Research Ltd. For the past year the work has been under the auspices of the National Research Development Corporation and their American licensees, Leesona Corporation and Pratt & Whitney. It is hoped that before long arrangements will be concluded with a British company for a greatly increased engineering development effort in this country.

**Exploratory work**

In the early stages the work was exploratory, the object being to demonstrate the technical feasibility of running high-temperature cells on a variety of carbon-containing fuels rather than to produce a cell for any specific application. This threw up a number of problems, most of which have now been solved, and paved the way to battery designs capable of being scaled up in size. Although large self-contained batteries have not yet been constructed, design data have been accumulated in the last few months to enable the next stage of engineering development to proceed.

Early work showed that with fused alkali metal carbonate electrolytes and sintered porous metal-metal oxide electrodes, it was possible to operate in the temperature range 500-700 deg C on carbon monoxide and gases containing carbon monoxide, at thermal efficiencies exceeding 60 per cent and current densities of about 75 A/ft$^2$ (808 A/m$^2$) with complete combustion of the fuel to carbon dioxide and water.

This was achieved in a multi-stage battery arranged so that the fuel flowed in series through six separate cells, one sixth of the fuel being consumed in each cell. As each cell has an open circuit voltage of about 1 V, the 6-cell battery produces 6 V on open circuit and about 4·5 V at a current drain of 75 A/ft$^2$ (808 A/m$^2$) of electrode area. Larger voltages can be produced by series connection of a larger number of cells.

This type of battery is very suitable for operation as a stationary unit on mixtures of carbon monoxide and hydrogen such as producer gas or synthesis gas. It is quite unaffected by sulphur or other gaseous impurities, and even quite large amounts of inerts such as nitrogen have only a small effect on performance. The only thing it will not tolerate is solid particulate impurities which deposit on the electrodes and block the gas passages.

For uses requiring a portable or transportable battery, or in cases where a piped gas supply is not available, we must think in terms of liquid hydrocarbon fuels. Operating data on kerosene are incomplete at present, but as far as they go, they indicate that it may be possible to run a battery directly on this fuel in the temperature range 500-700 deg C. We have no experience yet of operation on gas oil or diesel oil, but on general grounds there is a reasonable prospect of success. Liquefied petroleum gases such as propane and butane give serious trouble with deposition of solid carbon at temperatures above about 400 deg C, and unless the operating temperature can be reduced below this limit it will be impossible to run directly on these fuels. Some of the current work is directed to finding suitable fused salt electrolytes and more active electrodes for operation below 400 deg C.

However, there is one way of avoiding carbon deposition in the present operating temperature range which we have found to be perfectly feasible. If steam is injected into the fuel supply, the steam reforming reaction takes place:

$$C_3H_8 + 3H_2O = 3CO + 7H_2$$

At about 600 deg C this reaction occurs without much loss of free energy and in fact the electrical energy obtained when the reaction products, carbon monoxide and hydrogen, are consumed in the fuel cell is only a few per cent lower than would be obtained if the cell consumed the hydrocarbon directly. The presence of steam prevents the deposition of carbon. The overall heat balance is favourable because, although the steam reforming reaction is endothermic, the cell generates more than enough waste heat to cause the reaction to proceed. Excellent results have been obtained in this way with propane and also with methane. In practice it is likely that we would not use a separate steam supply, but re-cycle part of the reaction products from the cell into the incoming fuel feed.

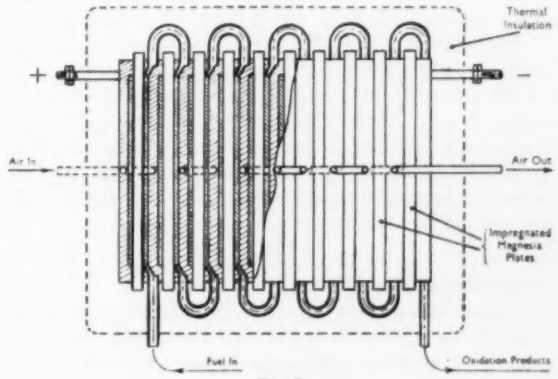



*Fig 2*

*Diagrammatic representation of the Sondes Place high-temperature fuel battery*

**Possibilities of Commercial Success**

To sum up the present position then, there are several low-temperature hydrogen-oxygen cells in existence which, with further engineering development, might become commercially successful if one is prepared to accept hydrogen as a fuel. There has been very little success with low-temperature hydrocarbon cells, but a substantial amount of research is in hand which might lead to a cell for special-purpose applications. Only the high-temperature cells are likely to be successful with cheap commercial hydrocarbons. Technical feasibility has been demonstrated with at least one type of high-temperature cell which is now ripe for engineering development.

**Some General Properties of Fuel Cells**

I want to turn now to some general considerations which have a bearing on the uses to which fuel cells will be put when they become commercially available, because many people tend to think that high efficiency is the sole advantage they offer over conventional power-generating processes. They have other advantages and, of course, they have some disadvantages.

The maximum available energy from the isothermal combustion of a fuel at a temperature $T$ deg absolute can be calculated from the expression

$$\Delta G = \Delta H - T\Delta S$$

$\Delta G$ is the free energy decrease in the reaction and $(-\Delta G)$ is the maximum useful work that can be obtained from the reaction. $\Delta S$ is the entropy change and $(-\Delta H)$ is the heat of combustion. A fuel cell does not operate on a thermal cycle and consequently the heat of combustion is irrelevant. The thermodynamic efficiency of a cell is expressed by the ratio of the electrical energy produced to $(-\Delta G)$. This differs from the engineers' thermal efficiency, which is based on $(-\Delta H)$, by an amount depending upon the sign and magnitude of $\Delta S$. This, of course, depends upon the chemical nature of the fuel. We can always translate thermodynamic efficiencies into thermal efficiencies if we know the value of $\Delta S$, the entropy of oxidation. With producer gas, for example, the thermal efficiency of a cell is about 80 per cent of its thermodynamic efficiency. In comparing fuel cells and heat engines it is important to bear this distinction in mind.

All satisfactory fuel cells have open-circuit voltages which are very close to the theoretical values, usually of the order of 1·1 V. This implies that at vanishingly small loads the thermodynamic efficiency is very close to 100 per cent. As with all primary cells, the terminal voltage falls as the load increases. This represents a loss of efficiency, some of the available energy being degraded to heat because of polarisation losses and internal resistance heating. The general relation between thermodynamic efficiency and load is shown in Fig. 1.

**Power Output of a Cell**

The maximum power output of a cell occurs when the terminal voltage has fallen to half its open-circuit value. Beyond this point, although larger currents can be drawn, the increased current is more than offset by the reduced terminal voltage and the power output falls. Most power-generating devices have an optimum output at which their efficiency is a maximum. The characteristic for a diesel engine, for example, would be more like the lower dotted curve in Fig 1. On a varying load its average efficiency would be considerably less than the maximum. The fuel cell has the advantages not only of a higher efficiency but also of a much more favourable efficiency/load characteristic under conditions of varying load. This would be particularly advantageous for traction applications.

In the equation given above the $T\triangle S$ term, which may be positive, negative or zero, represents the heat effect accompanying the reversible oxidation of the fuel. In other words it is the heat evolved or absorbed when a perfect cell runs at 100 per cent thermodynamic efficiency and produces an amount of electricity equal to $(-\triangle G)$. A practical fuel cell delivering a finite output will produce less than $(-\triangle G)$ units of electricity for the same consumption of fuel and the difference will appear as heat. The total waste heat evolved is the algebraic sum of this heat and $T\triangle S$. The removal of this heat poses quite a problem with large fuel batteries and may well be one of the factors militating against the use of large low-temperature batteries. Removal of heat from a high-temperature battery is a much easier proposition and, furthermore, as it is high-grade heat, it could be usefully employed. One could visualise an integrated high-temperature fuel-cell system supplying both electricity and high-grade heat.

Fuel cells lend themselves naturally to scaling up by multiplication of identical modules because high voltage can be obtained only by series connection of a number of identical cells This has advantages and disadvantages. On the one hand it means that once commercial units are available with outputs of a few kilowatts, the development of larger units should proceed quite rapidly. Mass-production techniques would clearly be called for. On the other hand, the difference in manufacturing costs per kilowatt output between large and small units is unlikely to be as large as it is, for example, in the manufacture of diesel generators.

The simplicity of fuel batteries, their lack of moving parts and silent operation require little comment. If the corrosion problems are overcome, they will have a long life and require very little in the way of maintenance.

**Battery Design—some Engineering Problems**

The Sondes Place high-temperature battery in operation at the present time is shown diagrammatically in Fig 2. The electrolyte is held in porous magnesia diaphragms to each face of which the porous electrodes are attached The diaphragms are interleaved between heat-resisting metal plates with recessed cavities in their faces arranged so that fuel and air can be fed over the back face of alternate electrodes. The cells are connected electrically in series through the metal plates. This experimental set-up is comparatively bulky. A more advanced design in which the intercell gas connections are made through the ceramic diaphragms, rather like the construction of a filter press, eliminates a great deal of the metal work and allows outputs of 2 to 2·5 kW/ft$^3$ (71 to 88 kW/m$^3$) of battery volume to be achieved at a thermal efficiency of 60 per cent. The ultimate limit of the present system appears, on theoretical grounds,

to be about 10 kW/ft³ (353 kW/m³). There is a good chance of achieving 6 or 7 kW/ft³ (212 to 247 kW/m³) in practice. The battery weight is of the order of 200 lb/ft³ (3·2 kg/dm³).

The biggest disadvantage of the high-temperature battery is that it is bound to require a fairly prolonged start-up period while the temperature is being brought up to the minimum operating value. We envisage that this will be done by burning fuel outside the cells and passing the hot combustion products through the battery. A 1 cu ft (28·3 dm³) battery heated in this way might require between ½ hour and 2 hours to reach operating temperature. On the other hand, under conditions of free cooling on no-load, it would take 8 or 9 hours to cool below the minimum operating temperature. Clearly such a battery would not be feasible for running a private motor car, but it would be quite adequate for continuous or intermittent use with idle periods not exceeding about 8 hours. During idle periods the temperature could, of course, be maintained by a slow feed of fuel with the battery short-circuited to give sufficient heat generation to compensate for radiation losses. The figures quoted above refer to an operating temperature range of 500-700 deg C. If it proves possible to reduce these temperatures by using alternative electrolytes, the start-up time will be considerably reduced.

**Problems of Cooling**

Once the operating temperature has been reached, the battery develops enough waste heat to maintain the temperature, provided that the unit is above a certain critical size. A 2·5 kW battery of the type described is self-maintaining in temperature when it delivers more than 0·5 kW. Above this output the excess heat has to be removed by cooling. This will be fairly easy in units with outputs of only a few kilowatts, but there will be some engineering problems in larger sizes because it may not be possible to remove all the waste heat in the combustion products without inter-coolers between banks of cells. Additional gas cooling channels in the batteries may be necessary. With hydrocarbon-steam feeds the endothermic nature of the steam reforming reaction will certainly help to solve the cooling problem.

Another group of problems which has not yet received much attention relates to the control of battery output. With most fuel cells this is not a simple matter of a throttle control on the fuel supply. This is too complex a subject to deal with briefly because, among other things which have to be considered, are the nature of the load and the ways it varies. It seems that each case will have to be treated on its merits. There is a great deal of engineering development to be done here to find the best way of combining automatic fuel metering devices with series-parallel switching of fuel flow to individual cells in a battery assembly.

**Some Economic Factors**

Fuel cells are only just emerging from the laboratory stage of development and any attempts to predict capital and operating costs are bound to be highly speculative. It is instructive, however, to consider briefly the economics of conventional power-producing equipment, because this at least fixes a target which must be reached if fuel batteries are to be competitive.

The most obvious competitors to the fuel cell are petrol or diesel-driven generators. Fig 3 shows how the average capital costs of such units vary with size. The cost per kilowatt rises very steeply for units with rated outputs below 20 kW. The first point to be made is that this is the range of sizes where fuel cells will require the simplest and cheapest ancillary and control equipment. This may well be the field where fuel cells have the biggest impact on the market in the early stages of commercial development. Petrol-driven generators are, on the whole, less efficient and more expensive to run than diesel generators and they tend to be used mainly for relatively small applications such as battery charging. This is a very obvious use for small fuel batteries.

According to the 1958/59 Report of the Diesel Engine Users' Association, the average fuel consumption of diesel generators ranging in size from 100 to 400 b h p was 0·585 lb (265 g) of gas oil per unit of electricity generated. The North of Scotland Hydro-electric Board operates diesel stations on the off-shore islands and in their latest annual report they quote a slightly lower figure of 0·523 lb (237 g) of oil per unit generated. The average United Kingdom price of diesel oil is 1s 4d per lb, so that the direct fuel costs are between 0·96d and 1·07d per kilowatt-hour. Lubricating oil, sundry stores and water add another 5 to 10 per cent to the fuel cost. Maintenance costs of diesel generators are fairly high and for a medium-size installation are equivalent to about 0·2d/kWh. Operating wages are difficult to estimate because they are very dependent upon the size of the installation and the load factor, but judging by figures given in the above report the charge for a medium-sized plant running at a load factor greater than 20 per cent might be between 0·15d and 0·25d per kWh.

Fixed charges to cover interest and amortisation are also dependent upon load factor. For an installation costing £20 per kilowatt and running at an average load factor of 20 per cent, the fixed charges at 20 per cent per annum would amount to 0·55d per kWh. This figure

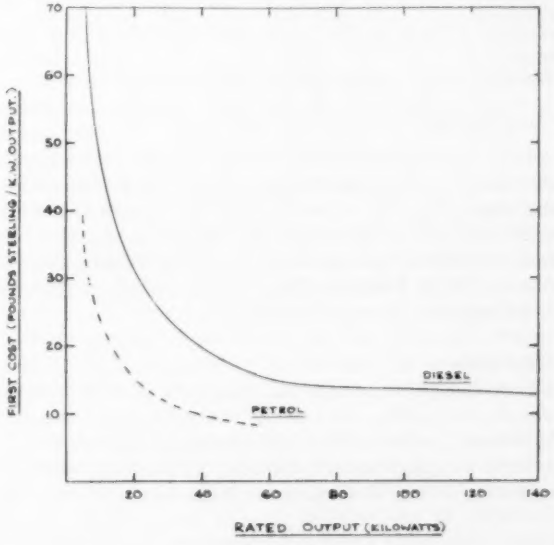



*Fig 3*

*This graph shows how the average capital costs of petrol- or diesel-driven generator sets vary with size*

is in line with those derived from the Scottish Electricity Board Report mentioned above.

The total running costs for diesel generators are given in Table 1.

**TABLE 1. Total Running Costs for Diesel Generators**

| | Pence per kWh | Percentage of total |
|---|---|---|
| Fuel | 0·96–1·07 | 49–50 |
| Lubricating oil, etc. | 0·05–0·10 | 2·5–5·0 |
| Repairs and maintenance | 0·2 | 9–10 |
| Wages | 0·2 | 9–10 |
| Interest and amortisation | 0·55 | 26–28 |
| Total | 1·96–2·12 | |

We see, then, that since the fuel cost represents 50 per cent of the generating costs, the fuel cell, with its greatly increased efficiency compared with diesel generator, will be a serious competitor even if its capital cost is higher, provided that it has a comparable working life.

Another factor to be borne in mind is that high-temperature fuel cells operate equally satisfactorily on a great variety of different fuels. It is of some interest to see how the nature of the fuel affects the generating cost in a fuel battery. Table 2 gives the current prices of a variety of fuels. The oil prices are taken from *Petroleum Times*, Aug 26, 1960 and refer to inner-zone deliveries in bulk. The figure for town gas is the average cost to the industrial consumer in the year 1959. The prices of liquefied petroleum bases (propane and butane) are current bulk prices. The figure for imported liquefied methane is a very tentative guess and may well be considerably in error.

**TABLE 2. Fuel Costs**

| Item | Approximate c v therm/gall | Price | |
|---|---|---|---|
| | | pence/gall | pence/therm |
| Light fuel oil (220 sec) | 1·62 | 12·875 | 7·95 |
| Gas oil | 1·615 | 15·375 | 9·3 |
| Light distillate | 1·6 | 16·5 | 10·3 |
| Kerosene | 1·5 | 18·0 | 12·0 |
| Petrol | 1·4 | 46·0* | 32·8 |
| Town gas | — | — | 15·45 |
| Propane | — | — | 26·5 |
| Butane | — | — | 24·2 |
| Methane | — | — | 5·5 |

* Including tax

Fig 4 shows the fuel costs per kWh for fuel-cell generation at four different cell efficiencies, together with the cost range for conventional diesel generation and solid-fuel-fired power-station generation (the latter taken from the 1959 Report of the South of Scotland Electricity Board). This is a striking demonstration of the economies to be expected from the fuel battery.

## The Future

I have tried in this paper to review the present state of the art; to outline some of the problems which have to be solved; and to indicate the advantages that fuel cells offer in comparison with methods of power production currently in use. In conclusion, I want to state my own feelings about the prospects for the future of fuel cells. We can confidently predict that commercial units will begin to appear on the market within the next five years. The first uses will clearly depend upon how low it proves

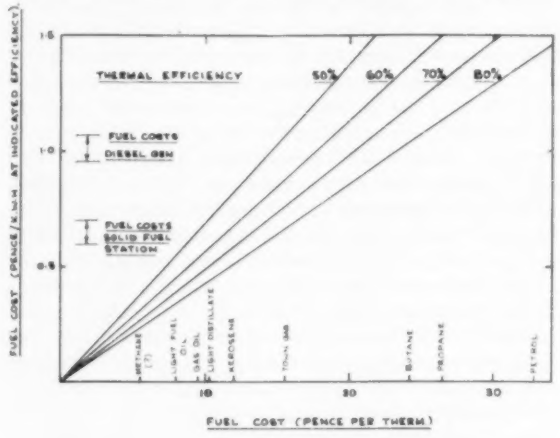



*Fig 4*

*Fuel costs per kWh of fuel cell generation at four different cell efficiencies compared with those of diesel and solid fuel generation*

possible to bring the capital cost, but it seems likely that the first batteries will be fairly small with outputs of about 5 to 10 kW. Unless there is a major break-through in the near future, the first cells will not run at low temperature on hydrocarbon fuels. This implies that they will not be rapid-starting units and hence will be unsuitable for uses such as powering motorcars. The most likely first uses are as a replacement for small diesel generators, or as substitutes for storage batteries for supplying fairly steady loads where rapid start-up is not important.

Fuel cells, of course, supply direct current and although this may be advantageous for traction purposes or for electrochemical processes, it is likely that, in general, d c/a c inversion will be necessary. Advances in semiconductor inverters during the next few years will be watched with interest.

The future of fuel cells for large central power station generation is an open question. This will not be among the first applications, but the possibility of long-term development cannot be ruled out in view of the recent revival of interest in fuel cells by the Central Electricity Generating Board, which has undertaken a detailed assessment of the matter.

**Acknowledgment**

This article was originally presented by Dr Chambers as a paper to the North-Eastern Coast Institution of Engineers and Shipbuilders on March 24, 1961, and forms part of the *Transactions* of the Institution, Volume 77, 1960/61. Acknowledgment is made to the Institution for permission to print this paper in THE BEAMA JOURNAL.

# The Tenth Electrical Engineers Exhibition

YEAR by year this event grows in size, scope and interest. This year a record number of exhibitors filled Earls Court in London and for the five days of the Exhibition they showed to a record number of visitors from overseas the enormous range of electrical equipment produced in Great Britain—from the highly-specialised micro-engineering of tiny electronic components to the large-scale engineering of power supply and distribution systems.

The opening ceremony was performed by the Rt Hon Frederick J. Erroll, M P, Minister of State, Board of Trade, and in the course of his speech he paid a tribute to the electrical industry for achieving a new record export total in 1960 amounting to £293 million.

Member-firms of The BEAMA* made up something like one-third of the total number of exhibitors and about three-quarters of the total stand area. This review of the Exhibition seeks to indicate the more important trends in design and development techniques as revealed by the exhibits of the various BEAMA member-firms. It should be noted, however, that the Exhibition is not confined to industrial and commercial products, but embraces electrical domestic appliances as well. As, however, many of the firms in this field were also showing at the Ideal Home Exhibition which was running at the same time, the new domestic appliances are dealt with in the review of that exhibition elsewhere in this issue.

Many of the stands at the Electrical Engineers Exhibition showed extensions to familiar product ranges, providing the customer with an even wider freedom of choice. New developments were on show too—a line-fault locator using radar principles, a variable-speed a c motor, and many others. Noticeable trends were the increasing use of plastics materials, the extension of unitisation and miniaturisation techniques, and the more widespread application of centralised control and remote indication.

The 'feature' exhibit was entitled 'Communications'. This was exemplified in the display by the British Transport Commission of a working model railway showing latest developments in overhead equipment and signalling, and by the General Post Office display of equipment for receiving signals from earth satellites.

**Materials**

A noticeable feature of the exhibition was the increasing range of applications being found for plastics materials by the electrical industry. Fibreglass Ltd, for example, were showing an end shield for a large switchgear-testing generator. The end shield measures 14 ft by 12 ft (4·25 m by 3·65 m) and is of double skin construction with a paper honeycomb forming the centre. A polyester resin reinforced with fibreglass chopped-strand mat was used for the moulding. The advantages achieved are considerable saving of weight and absence of eddy current losses.

*Visiting the stand of Pinchin, Johnson & Co Ltd after performing the opening ceremony, the Rt Hon Frederick J. Erroll (centre), who is a chartered electrical engineer, was very interested in this old dynamo made by Siemens in 1890 which formed part of the historical exhibit on this stand*

The use of glass textiles in high temperature electrical wiring and heating elements, already well established industrially, has now been extended to the domestic market. Examples from both fields were shown: a flexible heating element for temperature control of pipelines carrying viscous chemicals, oils and fats; and a domestic heating panel incorporating an element based on fibreglass woven cloth coated with colloidal graphite. Fibreglass yarns coated with polytetrafluorethylene (PTFE)—combining the excellent physical, chemical and electrical properties of both materials—are now being used for high-temperature applications up to 250 deg C in the form of covered conductors and cables, tapes and cloth.

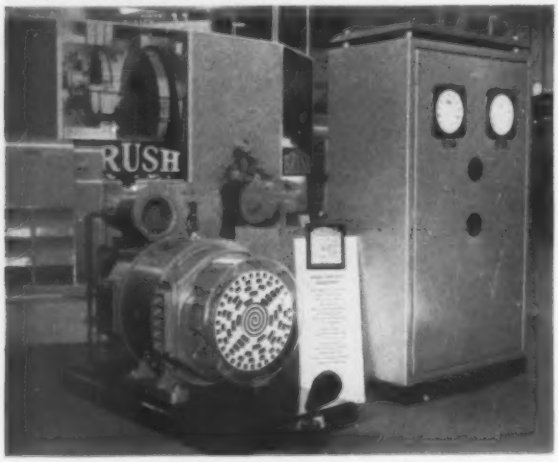
Permali Ltd displayed their 'wave-wound' glass fibre tubes for the first time. These are suitable for arc control pots, ducting, etc. Diameters up to 6 ft (1·83 m) and lengths of 20 ft (6·1 m)—or longer—can be supplied. The method of manufacture involves a technique known as filament winding in which glass rovings in parallel bands are wave-wound on to a mandrel so as to produce

* THE BEAMA JOURNAL, **68**, No 1, pp 22–23

a helical pattern. Epoxide or polyester resins are normally used to impregnate and bond the rovings. Straight, profiled, or tapered tubes can be produced. Very high hoop strengths are obtained.

The use of epoxy resin as a sealant was shown on a number of stands. Silicon epoxy-sealed low-power rectifiers are now being made by Ferranti Ltd. The type YS range has a mean current rating of 500 mA at 65 deg C ambient temperature, with a very high surge rating of 35 A for 5 ms.

A special feature of the Newmanseal motor—a new range of open-type electric motors produced by Newman Industries Ltd—is the use of resin-protected stator windings, a resin-protected rotor, and a sealed terminal box. The range extends from $\frac{1}{2}$ h p to 125 h p and an epoxy resin encapsulation process is used.




*This switched silicon rectifier motor speed control system shown by the Brush Electrical Engineering Co Ltd won the silver plaque for the best exhibit in the industrial section*

Materials for making cast resin cable joints were exhibited in kit form by British Insulated Callender's Cables Ltd. The kits are intended for plastics-insulated concentric-neutral cables. Compression conductor joints are used, doing away with the need for applied heat. The cast resin provides a tough yet rigid protective casing capable of withstanding severe physical impact. The tensile strength of the joint is equal to that of the cable.

The range of composite 'Silumite' asbestos tapes and papers produced by Turners Asbestos Cement Company Ltd has been extended by the bonding of glass cloths to asbestos paper impregnated with silicone resins. Hitherto such composite types, while very much stronger mechanically, have been limited to Class B conditions by the bonding resin. The new materials are suitable for Class C and Class H applications.

A. H. Hunt Ltd are now producing ceramic power capacitors direct from raw materials at their new Addington Works. They are suitable for most applications in induction and dielectric heating and radio transmitters. Largest in the range is 2 000 pF operating at 8·5 kV peak; further additions will be made to the range in the near future.

The use of aluminium foil for transformer windings was in evidence at the exhibition. Foster Transformers Ltd, for example, were showing a three-phase transformer, 440/150 V 365 A, with coils of anodised aluminium foil. A special coil-enveloping medium suitable for operation at 300 deg C was used.

**Control Equipment**

The control of industrial processes by electricity and the control of electricity itself were two fields of activity very much to the fore at the exhibition. Increasing use is being made of solid-state devices. New developments were to be seen in rotating machines. Efforts to make control gear itself easier to use were conspicuous.

A 'packaged' simple supervisory system was demonstrated by Standard Telephones and Cables Ltd. The system is designed for remote control and indication in electricity distribution networks, hydraulic works, dam intake gates, circulating water systems in steam generating stations, and for remote control application generally. It will work over 2 or 4 pilot cores—or equivalent voice-frequency or radio channels—and employs coded signalling. The facilities available include remote indication of the closing or opening of up to 16 electrical contacts and remote control of up to 16 functions.

The control station unit weighs 155 lb (70 kg) and measures 34 in by 27 in by 15 in (86 cm by 68·5 cm by 38 cm). The outstation unit weighs 180 lb (81·5 kg) and is the same size. The power supply unit in each case weighs 70 lb (31·7 kg).

**Telemetry Equipment**

Telemetry equipment designed to be intrinsically safe in underground mines was exhibited by Smiths Industrial Division. It is capable of transmitting electrical signals in analogue form over distances of several miles to an accuracy of $\pm 5$ per cent. The signals pass information to a central point above ground, indicating and recording various parameters such as current, temperature, running hours, etc. Based on the time division multiplex principle, the system minimises the number of conductors required in the cable from the locations underground to the surface. In order to transmit 36 signals, in six groups of six signals each from six distinct locations, only eight conductors are required in the main trunk cable. To satisfy the intrinsic safety requirement, transistor circuits operating at low voltage and power levels have been employed throughout.

The receiving equipment demonstrated utilised Smith's resettable synchronous-hours counters, which display the total period of time for which the amplitudes of the received signals exceed a predetermined level. This, for example, enables the total time that a machine has been running on load to be measured, as distinct from its running time when idling.

Automatic synchronisation of an incoming a c machine with the system to which it is being connected was demonstrated by the Instrumentation Division of A E I Ltd. Three units, using magnetic amplifiers, match voltage, speed, and phase. The speed matching unit (type SSM) produces either speed raising or speed lowering pulses of constant length once per speed-difference cycle. The pulses are of sufficient power level to operate either raising or lowering contactors directly,

or alternatively to provide direct operation of a shunt-wound d c 'speeder' motor. With the arrangement used, speed correction is proportional to speed error and very fine speed matching is easily obtained.

The voltage matching unit (type SVM) is arranged to produce either a voltage raising or lowering signal of sufficient power level to operate respectively either the raising or lowering contactors directly, or alternatively to provide direct operation of a shunt-wound d c excitation adjusting motor. The phase matching unit (type SPM) closes a master switching contactor when preset correlation of phase, voltage and speed is achieved.

The switching pulse is produced as a consequence of comparing the running and incoming supplies in a way that gives a beat envelope when there is relative speed. This envelope is rectified, smoothed and compared with a reference in such a way that when the instantaneous amplitude of the rectified envelope falls below that of the reference, a switching signal is initiated.

A further example of the packaged principle was to be seen on the stand of Mawdsley's Ltd. In this case it was packaged infinitely-variable-speed electric drives operating from a c. Ward-Leonard control is used for the armature of the d c work motor, together with regulation of its field by a thyratron rectification system.

The control system provides Ward-Leonard control of the armature together with field regulation of the work motor.

With the work motor at full field excitation, the armature voltage of the generator controls the speed of the work motor over the constant torque range up to the normal base speed. Thereafter the field strength of the work motor is reduced and the speed is increased over the constant horsepower range. Infinite speed variation of up to 25 : 1 is possible by armature control and up to 3 : 1 by field control (certain conditions may permit up to 6 : 1 by field control). The normal speed range of the work motor can be from 35 to 3 500 rev/min.

**Centralised Control Panels**

Many firms were exhibiting centralised control panels for the control of a number of electric motors. English Electric Ltd, for example, showed their new multi-motor control centres in which a standard range of control units, from fractional to 100 horsepower, can be accommodated on tiered swing-out or draw-out assemblies. For powers up to 400 h p the control units are mounted on fixed panels. Standard damp and dust protection facilities are included to comply with B S 587 : 1957.

The cubicles housing the control units stand 7 ft 7 in high (2·31 m). A standard motor control unit comprises stop-start push buttons, triple-pole isolators (to break stalled motor current), overcurrent relay, fuses, and main contactor. Interlocks ensure that no live terminals are exposed when the panels are open.

Torque and speed control of motors was demonstrated by Pye Electric Ltd. Their TASC unit* connects on to the output shaft of a motor and provides a standard speed range of 20 : 1. It consists of two independent rotating members supported in a fixed structure—about the same size as the induction motor driving it. The input shaft carries a rotor, and is driven at a constant speed. The output shaft carries the torque tube which surrounds the poled rotor. The fixed structure consists of the casing ring and a coil.

When a d c current is passed through the coil, a steady rotating magnetic field is set up. Electrical currents, and thus another magnetic field, are induced in the torque tube; the two fields interact to produce a torque on the output shaft.

The torque is proportional to the value of the coil current, and is nearly independent of speed. This feature permits either controlled speed, or controlled torque, or both.

*The silver plaque for the best exhibit in the domestic section was won by Easipower Appliances Ltd for their 'Dreamland' three-heat electric blanket displayed on this stand*

A trend noticeable at the exhibition was the greater attention being paid to the design of sensing heads. For instance, Lancashire Dynamo Electronic Products Ltd showed a transistorised level control unit, series TLCI. The unit works on the principle of detecting a change in electrical capacitance at the probe electrode mounted in the tank under control. A change in electrical capacitance occurs when an uncovered electrode is covered by the material to be detected or vice versa. The head contains a rugged transistor oscillator circuit which is fed with 12 V d c from the main control unit. The change in the conditions in the transistor oscillator when the material covers or uncovers the probe is detected by a simple transistor amplifier which in turn operates the relay in the main unit.

Mounted on the exterior of the probe unit and outside the tank is the head unit which contains the transistorised circuit elements. The cables from this head unit can be run over any distance to the main unit and have to carry only a few milliamps at 12 V. No special precautions have to be taken in running these cables. The main unit can be mounted at any desired position and contains the relay which operates when the probe is either covered by material or uncovered, depending on whether a high level or low level head unit is in use.

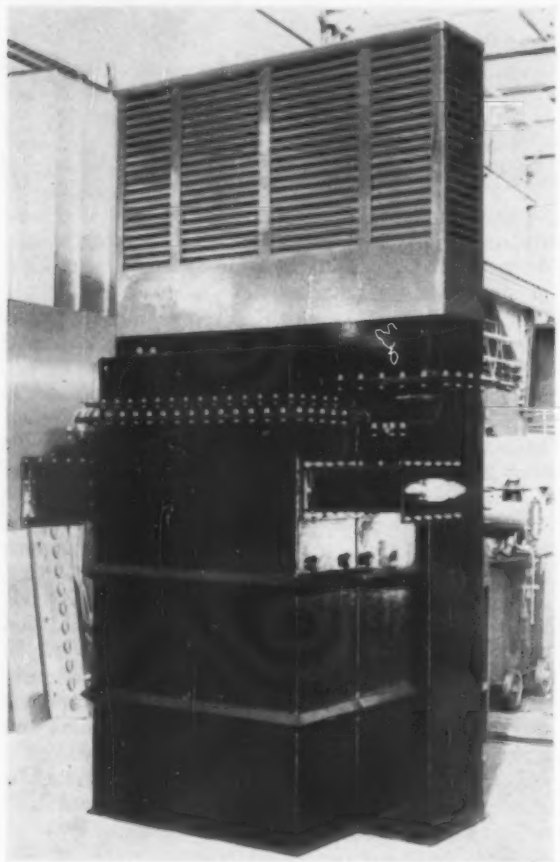
**Proximity Switches**

A proximity switch for detecting the presence of metal was shown by Donovan Electrical Co Ltd. The unit (type CE32) uses a sensing coil unit that is com-

* THE BEAMA JOURNAL, **67**, No 1, p 32

pletely sealed and may, when the need arises, be operated submerged in suds or oil. Swarf or metallic dust have no effect on the operation of the sensing coil. Six feet (1·83 m) of coaxial cable connect the coil to a control unit housing a relay normally fitted with two changeover contacts of 250 V 5 A rating. With this arrangement, up to five operations per second are possible. A special sensing coil is available for use as a tool-breakage detector on drilling or tapping machines.

Protection for users of small electric tools was offered on the stand of Siemens-Schuckert (Great Britain) Ltd. They produce monitor units that switch off a tool if a fault occurs in its earth line. Their latest development is a multi-outlet monitored earth circuit system that enables one master unit to be used for a number of tools. This is made possible by the use of a special interlocked switch-plug outlet for each tool. Another feature of the exhibition was the growth in equipment for taking advantage of off-peak tariffs. Robert Mac-Laren and Co Ltd, for example, were showing a new range of thermo-time regulators, types TA and TC. They automatically vary the amount of heat stored by an electric heating system to suit the outside temperature, and at the same time ensure that the charge takes place towards the end of each off-peak period. The TA is the simplest type. It employs a bi-metal temperature detecting element, the movement of which is used to vary the switch closing time with outdoor temperature in accordance with a cam programme. A synchronous clock motor rotates the cam once every 25 hours. Adjustment of a temperature-setting dial brings the heat on earlier or later. The instrument switch can handle 15 A at 250 V a c or 12 A at 440 V a c.



*An example of the latest development in directly buried transformers by Hackbridge and Hewittic Electric Co Ltd. The capacity of the unit shown is 500 kVA 3-phase, 11 000/433 V, but capacities up to 1 000 kVA are also available*

**Cables**

Interest in the cable exhibits at the Exhibition centred on the proposed cross-Channel power link.* A £610 000 contract for cross-Channel power cables has been placed by the Central Electricity Generating Board with Associated Electrical Industries Ltd and British Insulated Callender's Cables Ltd. These two firms will lay half of the cross-Channel submarine power cable link which will connect the national electricity systems of Britain and France. As planned, the connection will transfer 160 MW of d c power from one system to the other at peak periods and transfer power at other times to meet conditions such as surplus or shortage of water at hydro stations.

The direct current transmission will operate at 200 kV between poles, with its centre point earthed, and the cables will be insulated for a nominal voltage of 100 kV to earth. The normal full load current will be 800 A with a 20 per cent overload for isolated periods of 30 minutes.

The cables themselves, as developed successfully from sea trials, are of the impregnated paper insulated solid type. The submarine cable conductor is of 0·525 square inch (339 mm$^2$) in cross-section and consists of stranded copper wire lapped with an electrostatic screen. The solid type impregnated-paper insulation, also lapped externally with an electrostatic screen, is sheathed with lead alloy 'E' which is protected against corrosion by vulcanised rubber tapes. Armouring is provided by a single layer of 0·232 inch (5·89 mm) galvanised steel wires with appropriate beddings and servings. The cables weigh about 39 lb/yard (19·3 kg/m) in air and about 25 lb/yard (12·4 kg/m) in sea water.

**Design Stresses**

Anti-twist tapes will be applied over the lead sheath and under the anti-corrosion protection, these tapes being necessary to ensure that the cable is not damaged under the excessive tensions that may be required to lift the cable out of the sand on the sea bed during recovery after a possible fault. The design stress of these cables is about 150 000 kV/cm at ambient temperature.

The inferior heat dissipating properties of the soil compared with those of the sea necessitate the use of a larger conductor size for the land cable. Over sections of the route where the normal type of loam is found a conductor size of 0·6 sq in (3·87 cm$^2$) will be employed, but in the shingle areas which have very poor thermal dissipation properties, a 0·925 sq in (5·97 cm$^2$) conductor will be necessary.

Further developments in cable jointing techniques were shown on a number of stands. Pirelli-General Cable Works Ltd showed a new straight joint for 33 kV three-core cable. It has been designed to satisfy a long-

* THE BEAMA JOURNAL, **65**, No 4, p 164

felt need for a 33 kV normal solid or MLND cable joint of compact fully-screened design, which could be made quickly in the field and which would not make great demands on the skill of the jointer.

The core insulation is stepped down in two short chamfers, and easily applied crêpe paper tape is used to build up the joint insulation, most of this tape being 2 in wide (5 cm) to speed up the taping process. The use of crêpe paper tape enables the direction of taping to be reversed easily at the end of each layer and obviates the necessity for straightening the cores. The jointed cables are screened with tinsel stockings which readily adapt themselves to the shape of the cores and the joint is enclosed in a copper sleeve. The copper sleeve can then be protected by either a concrete or fibreglass box.

**Switchgear**

Equipment for performing switching operations extended in size from the very small to the very large—from micro switches to 275 kV isolators.

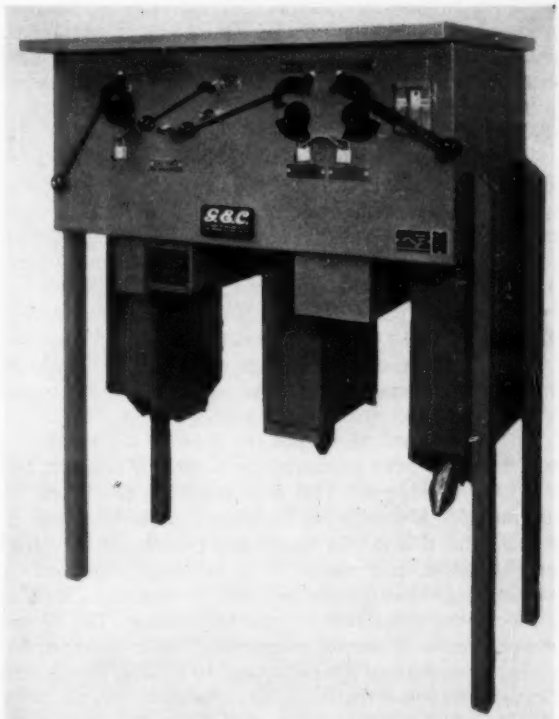
It was on the stand of the Switchgear Division of A E I Ltd that one phase of a 275 kV 15 000 MVA centre-rotating-post isolator was exhibited. The type CI 300 isolators are designed for indoor service and have a normal current rating of 2 000 A. They have an impulse withstand level of 1 050 kV to earth and 1 210 kV between phases and across the gap; under fault conditions they will withstand a peak current of 80 000 A and carry a symmetrical current of 31 400 A for three seconds.

The isolators are of 3-post design, the centre post being rotated by direct mechanical drive from a hydraulic operating mechanism and carrying a double-ended copper tube blade. The outer posts carry the fixed contacts; all contact surfaces are silver plated. The insulators are of the seven-unit pedestal type, the upper three units of each post being fringe-resistance glazed to provide stress control.

The mechanism rotates the centre post and blade, through an angle of 70°, from the 'isolator open' position to the 'isolator closed' position. The blade, having flattened ends, freely enters the fixed contact fingers, its travel being checked by resilient stops. The centre post then rotates a further 20°, giving the blade an axial twist which forces the contacts apart and thus establishes the necessary contact pressure.

The Transformer Division of A E I Ltd exhibited a type LA transformer on-load tap changer. The complete tap changer is built up as a single ironclad oil-immersed unit bolted to the transformer tank. It is designed for circuit voltages up to 33 kV with currents not exceeding 200 A.

Each phase of the switch consists essentially of two moving contacts and a series of fixed contacts connected to the transformer tappings through terminals on the barrier board. Two Geneva wheels each independently operate one of the moving contact arms. The spacing of the Geneva wheel operating pins ensures that the motion of one arm is completed before that of the other is started. A resistor momentarily bridges the two tappings during the change. When a tap change is completed, both arms are in contact with the same tapping of the transformer winding.




*The 11 kV switch-fuse ring main unit introduced by the General Electric Co Ltd of England. The unit has a certified breaking capacity rating of 250 MVA at 11 kV*

The starting current of the single-phase capacitor motor driving the switch is small enough to permit operation from the voltage-regulating relay. With the standard scheme for remote electrical control, tap changes are initiated by a preselector control switch having numbered positions corresponding to those of the tap changer. When the control switch is turned to the required position number, the tap changer runs to that position.

**New Switch-fuse Ring Main**

Shown for the first time by the General Electric Co Ltd of England was a new 11 kV switch-fuse ring main unit. This is made up of two ring oil-immersed switches and a switch-fuse tee-off unit. The oil switches are rated at 400 A and tee-off at 60 A (maximum) at 11 kV. Certified breaking capacity is 250 MVA at 11 kV. Operation of any fuse causes the tee-off switch to trip. Bushings are built in the unit to enable cable testing to be carried out. The unit is suitable for indoor or outdoor use and the fuses, which are air-insulated, can be replaced even if it is raining.

A new multi-pole relay for motor control was displayed by J. A. Crabtree and Co Ltd. At 415 V a c the type G relay has a contact life of 5 million operations at 1 A non-inductive load or 1·5 A inductive load. Two four-pole patterns are available, one with normally open and the other with normally open and normally closed contacts. Currents up to 10 A can be switched.

The M C B Co (Manchester) Ltd have now brought out double- and triple-pole versions of their 'Midget' miniature circuit-breakers. Both are built up from

complete single-pole breakers. The operating mechanisms are linked externally; the trip mechanisms are linked internally, the hole for the link pin being the only communication between adjacent poles. The units are available at current ratings up to 60 A and for up to 400 V a c.

A new earth-leakage protection unit was shown by Chilton Electric Products Ltd, designated the type C earth leakage circuit breaker. Concise test instructions are prominently displayed on the face of the instrument and a large push-to-test bar has been incorporated. Ease of installation is improved by the fact that it can be wired either through top or through bottom terminals. Ratings up to 100 A are provided in a single frame size.

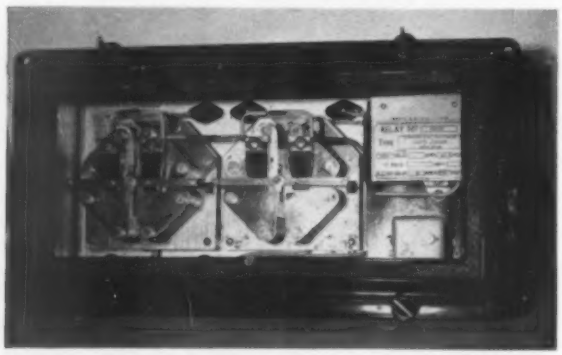
An electrostatic earth-leakage relay for use on wholly insulated systems was shown by Nalder Bros and Thompson Ltd.

Among the microswitches on show at the exhibition was the type MM produced by Robert MacLaren and Co Ltd, of Glasgow. This was originally developed for aircraft use as a long-life, miniature, side-stable microswitch, but it also has many applications in industrial and domestic equipment. It is inherently side-stable, with a single through plunger; and no external sliders or push rods are required to give this action. The switch mechanism is a simple overcentre toggle arrangement giving a mechanical life of around 10 million operations. On resistive loads the breaking capacity is 5 A at 250 V a c, provided switching is no faster than 10 cycles/min.

**Instruments**

Trends noticeable in the instruments displayed were increasing use of electronics, and miniaturisation. There was also an increase in the amount of remote indicating equipment shown and of the off-peak metering equipment.

Electronic summation metering equipment for use in power stations, sub-stations and other bulk supply points were exhibited for the first time by Ferranti Ltd at this year's Exhibition. The main feature of this equipment is the replacement of electromechanical summation by electronic methods. The conventional mechanical contactors fitted to watt-hour meters are also replaced by photo-electric devices. The check and total registers are driven by an electromagnetic stepping motor, so there is no need for mechanical links such as contactors and ratchets. Mechanical maintenance, therefore, is very much reduced. In addition, the electronic equipment can drive existing electromechanical equipment and vice versa.



*The new 'Nalder' electrostatic earth-leakage relay indicator*

The summator, which permits a very large saving in panel space, can accommodate up to 18 display registers, giving 16 channels and 2 totalisers. The printed circuits used in it are standardised and servicing and modifications of schemes can be carried out quickly and simply. The increased rate of impulsing—10 per second compared with 1 per second—enables each pulse to represent smaller units of power, thus providing greater overall accuracy at any given instant.

**Line Fault Locators**

Ferranti Ltd were also showing new equipment ordered by the South of Scotland Electricity Board and the North of Scotland Hydro-Electric Board. These are a c type line-fault locators* for detecting the position of permanent and transient faults, including flashovers between conductors, on high-voltage transmission lines. The locators also detect the presence and position of icing and conductor oscillation.

The locator operates on the radar principle of pulse reflection from the point at which the abnormal line condition exists. The reflected pulses are displayed on a cathode-ray tube. The distance down to the end of the fault is determined by measuring the time interval between the sending of the 1 Mc/s pulse and the reception of its reflection. Accuracy of the locator is 1 per cent of the line length, or 3 000 ft (914 m), whichever is the greater.

To meet the increasing demand for further reduction in the panel space occupied by recording instruments, a dwarf version of their well-known 'Inkwell' recorder has been developed by Everett Edgcumbe and Co Ltd. Designed for flush mounting in a 6 in (15·2 cm) square cut-out, the space required overall is only 7 in by 7 in (17·8 cm by 17·8 cm). In spite of these small dimensions, the width of the chart has been maintained at the standard width used in the 'Inkwell' range, namely 4 in (10·2 cm).

Various movements are available: moving coil, for d c recording of microamperes, milliamperes, amperes, and volts; moving-coil rectifiers; moving-coil rectifier-bridge; and induction movements for recording power in a c systems.

A miniature high-sensitivity recorder (type 231) was shown by Elliott Brothers (London) Ltd. Its sensitivities range from 500 μA full-scale. Chart speeds between 1 in/hr and 36 in/min (2·54 cm/hr and 91·5 cm/min) are available; the chart writing width is 3 in (7·6 cm).

Evershed and Vignoles Ltd exhibited a new transistorised quick-response recorder. The instrument, which is of the continuous roll chart type, contains two movements that are essentially d c recording voltmeters having a rapid response and negligible pen-to-paper friction. The recorder is servo operated and works in conjunction with an amplifier unit.

The instrument will record sine wave voltages up to 25 c/s with an amplitude error not exceeding 10 per cent for a peak-to-peak amplitude of $1\frac{1}{2}$ in (3·8 cm). At smaller amplitudes the frequency response is proportionally higher. The linearity is within $\pm 3$ per cent. The

* THE BEAMA JOURNAL, **67**, No 3, p 122

drift, after an initial warming-up period of half an hour, is less than 1 per cent of the full-scale deflection.

To make things easy for meter readers in large blocks of flats, Smith Meters Ltd have developed remote indicators for domestic meters. Thus in a large block of flats, each flat has its own electricity-consumption meter but at the same time remote indicators grouped on a board in the basement or other convenient location show the reading of each meter.

The repeater register is an extremely simple device operating on a 3-wire a c circuit and avoiding the use of rectifiers and pawl and ratchet mechanisms. The impulsing meter comprises a meter fitted with a changeover contacting device. The contacts are magnetically assisted to provide a definite minimum contact pressure and quick make-and-break action. The repeater register comprises a five-figure counter of the cyclometer type reading directly in kilowatt-hours. A soft-iron rotor, directly connected to the first roller, is advanced in one digit steps by two electromagnets; apart from this rotor there are no moving parts additional to those in the register.

The same company also showed a new single-phase two-rate meter for the separate registration of energy consumed during peak and off-peak periods. The two-rate register consists of two 6-pointer trains, a clutch mechanism and solenoid. Mechanical drive from the meter rotor to each register train passes through friction clutches, either of which can be disengaged by the solenoid. The normal or day-rate register is engaged when the solenoid is de-energised, and the low or night register is engaged when the solenoid is energised.

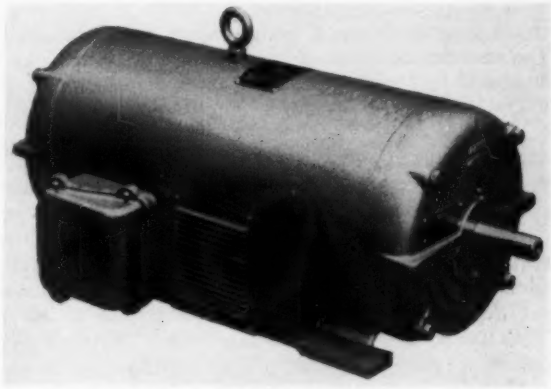
**Motors and Generators**

Study of conventional motors exhibited showed extension and consolidation of existing ranges. A E I (Rugby) Ltd, for example, demonstrated totally enclosed machines with Class E insulation* and 65 deg C temperature rise in accordance with B S 2613 : 1957 in ratings from ½ to 200 h p. The upper limit of totally-enclosed fan-cooled machines to B S 2960 : Part 2 was represented by type KN-D 326—40 h p at 1 500 rev/min.

A significant development demonstrated at the Exhibition was a variable-speed single-phase a c motor. Known as the Mawdsley-Mensforth motor, it is produced by Mawdsley's Ltd and can be smoothly varied in speed between 0 and 3 000 rev/min. Torque is constant down to zero speed. At present, motors between 1 and 5 h p are being produced.

The motor is a commutator type in which the speed control is obtained by varying the armature voltage by means of a variable transformer. The main exciting winding is tuned with a capacitor so as to bring the flux into alignment with the mains supply voltage. The stator or field system is of the distributed type, and is provided with main exciting windings, neutralising windings, and series and shunt interpole windings. Near the top of the speed range, when the voltage supplied to the armature by the variable transformer is high, the shunt interpoles are fully effective. The 'transformer' volts are neutralised and the parasitic currents due to brushes short-circuiting commutator bars are small. The

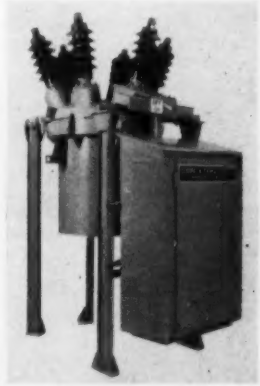
* THE BEAMA JOURNAL, **67**, No 1, p 37



*An air-cooled 'Ajusto-Spede' drive motor, nominal 2 h p, shown by Heenan and Froude Ltd*

exciting field circuit, which is tuned by the capacitor, therefore has a high Q; that is, the voltage applied is small in comparison with that appearing across the field windings. At low speeds, however, the Q falls and so, in order to maintain the exciting field current correct in magnitude and phase, the voltage applied must be increased. This is achieved by a small autotransformer operating in conjunction with the slider of the main variable transformer.

The mains supply power-factor does not fall below about 0·86. The variation of the motor characteristics with speed are such as to make it ideally suited for applications like small planing-machine table drives where a stable low speed is required for cutting and a high speed for the idle return, together with regenerative braking. An added attraction is the motor's ability to carry up to 100 per cent momentary over-loads at any speed without commutation or other troubles.



*Crompton Parkinson Ltd exhibited this OE 1 triple-pole 33 kV oil circuit-breaker. This new switchgear unit has been specially designed to meet the exacting conditions in overseas markets. It has a rating of 500 MVA at 33 kV, with 800 A maximum current*

Mawdley's also exhibited a generalised electrical machine suitable for teaching purposes. The machine, developed in association with Dr J. E. Brown of Bristol University, is capable of being connected in a number of ways to provide a complete set of a c and d c motor and generator characteristics.

A vertical-spindle 250 kW 10 kc/s motor-generator for induction heating and similar applications was exhibited by the Electric Construction Co Ltd. The set consists of a squirrel-cage motor and an a c generator, with their two rotors mounted on a common vertical shaft so that the combined set occupies a minimum of

floor space. Cooling is effected by means of a closed-air circuit incorporating a water-cooled heat exchanger. The sets can be supplied for frequencies up to 10 kc/s and with fast response times, where quick changes of load demand rapid control of output voltage.

**Miscellaneous**

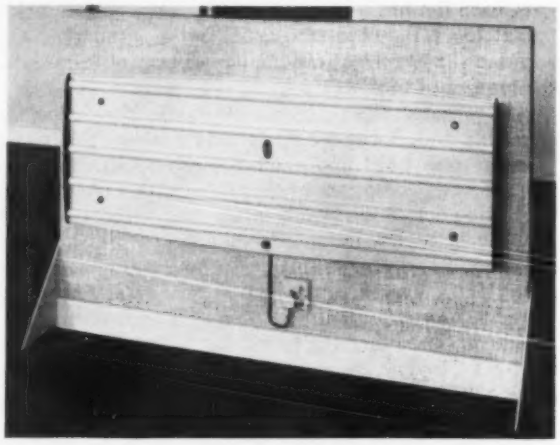
Standard Telephones and Cables Ltd showed a newcomer to the range of SenTerCel equipments—a constant current battery charger using silicon rectifiers and incorporating transductor control. This charger operates from 200-250 V 50 c/s supply and gives an output sufficient to charge up to 32 lead-acid cells at 30 A. The same company also showed a 500 kW silicon rectifier equipment giving an output of 225 V for d c substation use.

Modular high-voltage rectifier columns capable of delivering up to 1 kW/in$^3$ (61 W/cm$^3$) were shown by the International Rectifier Co (Great Britain) Ltd. Ranges from 10 to 120 kV and 1 to 50 A are available. Shown at the Exhibition was a column giving 9 A at 30 kV. The basic column module is a polyester glass board containing two silicon rectifier cells, voltage dividing circuitry, connectors and heat dissipating shield. Applications include long-range radar, high voltage d c resistance welders, and pulse-forming circuitry for plasma research.

Chloride Planté cells of 1 000 Ahr capacity were shown by Chloride Batteries Ltd. It is difficult to get good quality glass mouldings for this size of battery and this is the first time the company have used such a size of box. An order is in hand from the G P O for two 50 V batteries of this size. Design of a 1 200 Ahr sealed moulded-glass battery is under way.

A 20-line private electronic telephone exchange was exhibited by Pye Telecommunications Ltd. It contains no moving parts whatsoever and is completely silent in operation; special location of the exchange is not necessary. It is of unitised construction and rapid replacement of interchangeable plug-in panels is possible in the event of service faults. Cold cathode tubes are used for the ringing, speech passing, and logical control circuits. Ringing current is provided by a transistor generator working at 17 c/s.

*A vertical spindle 250 kW 10 kc/s motor-generator for induction heating and similar applications exhibited by the Electric Construction Co Ltd*



*One of the heating units shown by Heatrae Ltd was this Heatrae 'Sleekline' decentralised heating unit. It won a 'highly commended' award in the domestic exhibits section*

New multi-purpose industrial infra-red heaters were shown by E. K. Cole Ltd. The design permits the use of either one, two, or three element-reflector assemblies with a common spine. Each fixed-focus reflector assembly is independently adjustable in relation to the spine, so that the heat distribution can be arranged as required. Interchangeable 1 kW or 1·5 kW metal sheathed elements are used.

A new range of radiant heaters was also shown by the Transformer Division of A E I Ltd. The 'Slimline', as it is called, uses the well-known A E I Pyrobar element. The aluminium reflector has an anodised mirror finish and is parabolic in shape, giving a 50° beam angle.

G E C showed a new range of commercial light fittings, named 'Executive', in which a relatively small number of basic components provides a great many different assemblies. Simplex Electric Company Ltd showed the new 'Airflo' range of high-bay lighting fittings, which accommodate mercury fluorescent lamps from 250 to 1 000 W. This range has a self-cleaning spun aluminium reflector and a glass fibre insulated canopy. A E I Lamp and Lighting Co Ltd showed five 'Automat' vending machines for electric lamp bulbs.

Direct buried transformers can now have larger capacities. By use of an associated cooling unit above ground, Hackbridge and Hewittic Electric Co Ltd are now making available transformers at standard distribution voltages and capacities up to 1 000 kVA.

The spread of automatic control has brought changes in the plug and socket industry. William McGeoch and Co Ltd, for example, are now producing plugs and sockets with 406 pins; the design of 500 pin units is in hand. They are intended for 250 V or, when fitted with P T F E interiors, 440 V. Pins and tubes are hard gold plated and are rated at 2 to 5 A.

# Notes

**The B E A M A Guide to Arc Welding Electrodes**

The British Electrical and Allied Manufacturers' Association has published a new and completely revised 100-page edition of their 'Guide to Arc Welding Electrodes', which is designed to assist the user in the choice of suitable electrodes for each purpose. Outstanding technical advances in engineering construction have been made possible by welding techniques, notably in the construction of nuclear power equipment, and the greater specialisation that is taking place is increasing the demand for information on electrodes.

The guide was first published in 1944 and this is the sixth edition of this publication, giving in a convenient form classified lists of British electrodes and a key to American and British Electrode Standards.

To assist consumers in choosing the correct electrode for a particular application there is included in the Guide a brief description of the British Classification of Electrodes, published by the British Standards Institution as B S 1719 : 1951.

In this issue a more complete description of the American method of classifying electrodes is given, and the equivalent American Code numbers are shown in all the classified lists.

For those interested in electrodes for welding non-ferrous metals, cast iron, corrosion resistant and other steels, a section is included which gives information on special electrodes and lists of the special electrodes available.

The guide costs 5s 0d (including postage) and copies can be obtained from The BEAMA, 36 Kingsway, London, W C 2.

**B I C C Corrugated Aluminium-sheathed Cables f r the Commonwealth**

From widely separated parts of the Commonwealth, British Insulated Callender's Cables Ltd have received two interesting contracts, each calling for the supply of oil-filled cable with corrugated seamless aluminium sheath protected overall with an extruded P V C jacket.

The installations are at Bulimba, near Brisbane, Queensland, and on Vancouver Island, British Columbia. In each instance it will be the first installation in Australia and Canada respectively of oil-filled cable with corrugated aluminium sheath designed and manufactured by B I C C.

The Australian contract, placed by the Southern Electrical Authority of Queensland, covers an installation for operation at 33 kV and includes both single and 3-core cables and the provision of accessories of B I C C design. The cables will be installed on open reinforced concrete shelves in an underground ventilated tunnel.

The Canadian contract was placed by the British Columbia Electric Company Limited and is for single-core cables to operate at 138 kV between Horsey Sub-Station and Stratford Sub-Station on the outskirts of Victoria, the capital of British Columbia. Two circuits are to be installed complete with the necessary accessories and the cables will be drawn into ducts. Installation will be carried out by the Phillips Electrical Construction Co Ltd (a member of the B I C C Group).

Early this year B I C C were awarded a $7 million contract from the Magna Pipeline Company Ltd of Vancouver B C, to manufacture, install and commission 53 miles (85·29 km) of flexible submarine pipe to transmit a supply of natural gas from the mainland of British Columbia to Vancouver Island.* In 1956 B I C C laid 93 miles (149·6 km) of high-voltage submarine power cables along a route almost parallel to that of the new pipeline. These cables, together with 42 miles (67·5 km) of similar cables installed in 1958, have given continuous service.

**Pumps and Electrical Equipment on Floating Dock for Poland**

Centromor, the Polish Government organisation for import and export of ships, floating docks and marine equipment, has ordered a 5 500-ton lifting capacity floating dock from the Furness Shipbuilding Co Ltd.

The dock, which is destined for the United Ships Repair Yards at Gdansk in Poland, is to be equipped with four 22 in (55·8 cm) de-watering pumps together with two fire pumps and exhausters, to be manufactured by Gwynnes Pumps Ltd of Hammersmith and Lincoln, with electric motors and control gear to be supplied by W. H. Allen Sons & Co Ltd of Bedford.

**Latest Design of Air-Blast Switchgear for the Super Grid**

Orders worth about £700 000 have been received from the Central Electricity Generating Board by English Electric for equipment for supergrid switching stations at Sundon, Bedfordshire, and Feckenham, Worcestershire. The two 275 kV switching stations will be equipped with ten of the latest design of air-blast circuit breakers rated at 15 000 MVA 2 000 A. They will be made at the Stafford works of the English Electric Co Ltd.

One of the new units is also being manufactured there for the Connah's Quay switching station in Flintshire, which is at present equipped with breakers of the earlier 7 500 MVA design.

The 275 kV 15 000 MVA 2 000 A air-blast circuit-breaker, designated rT6C, is the first of a range of air-blast breakers manufactured by English Electric which will cover voltages from 132 kV up to 550 kV or even higher.

These breakers are fully pressurised throughout in both the open and closed positions and do not incorporate a make switch, which is a feature of all current British air-blast breaker designs including those manufactured to date by English Electric. This innovation, coupled with the fact that the breakers are mechanically operated up to the last stage, ensure very high performance. The circuit-breaker is guaranteed re-strike free and at all voltages has a total break time of 2½ cycles maximum.

The various voltage ranges are covered by using multiples of the same interrupter, which can be supplied for current ratings up to 4 000 A. The 275 kV 15 000 MVA breaker incorporates six interrupters. The interrupters are shunted by linear switching resistors and also by capacitors for ensuring voltage division when the breaker is in the open position.

**First Scottish 275 kV Circuit-breakers**

The nine 275 kV air-blast circuit-breakers ordered by the South of Scotland Electricity Board for Strathaven switching station are being assembled for delivery at the Hebburn Works of A. Reyrolle and Co Ltd. One of these was short-circuit tested recently for a rating of 7 500/10 000 MVA to the satisfaction of the Board's engineers.

These will be the first 275 kV breakers to be installed in Scotland. Five similar breakers will be supplied to Windyhill Substation, and these two installations will form the first part of the 275 kV supergrid in the South of Scotland.

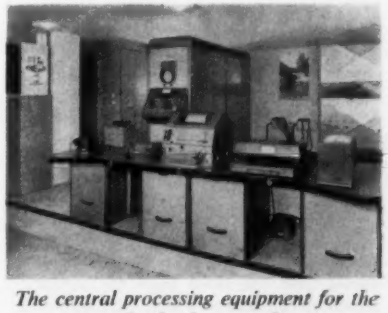
It is expected that the Strathaven switching station will be in commission early in 1962 to provide power for the Colville strip mills at Ravenscraig.

**New Aircraft Load Control Computer now in Operation**

The first electronic computer system in the world for aircraft load control and passenger check-in has now been brought into operation by Scandinavian Airlines System at Kastrup airport, Copenhagen.

This system, which has cost about £100 000, has been designed to the special requirements of S A S, and was designed, manufactured and installed jointly by Standard Telephones and Cables Ltd, London, and its associated Company—Standard Elektrik Lorenz, of Stuttgart.

In modern airline operation it is very important to know the weight of baggage of each passenger and where it is to be loaded in the aircraft. Knowing the number of passengers and their combined baggage weights, it is possible to obtain an overall picture of the total load to be carried by the



*The central processing equipment for the new aircraft load control computer system at Kastrup airport, Copenhagen*

* THE BEAMA JOURNAL, **68**, NO 1, p 7

aircraft and the distribution of this load. When these figures are available in time, the operating airline is able to use spare capacity by loading and carrying revenue earning freight and/or mail.

For this information to be of any value it must be speedily available at some given time before take-off. With a manual system, either the number of check-in points must be limited, or passengers must present themselves and their baggage an inordinately long time before take-off, otherwise a very expensive system of document handling must be introduced.

The new electronic computer system collects check-in data from all counters; computes and totals this data to provide the information needed for the compilation of aircraft load sheets; and prints out load sheets, load messages etc for each destination of every flight departing from Kastrup.

The advantages of such a system are (a) freedom to check-in at any counter for any flight, (b) instantaneous collection of data from all check-in points, (c) flexibility of calculations so that the different requirements of different aircraft can be catered for by high-speed computation of load data, (d) since there is no manual intervention between the actual check-in and the production of results, there is less chance of error, (e) results are available quickly, enabling a more economic loading of the aircraft (*e g* more freight can be carried), (f) the system is capable of expansion and extension.

The equipment consists of the Stantec Zebra computer (providing the central control, the data storage and the necessary computational facilities) connected to input sets at the check-in counters, and master sets (for input and output) at Load Control.

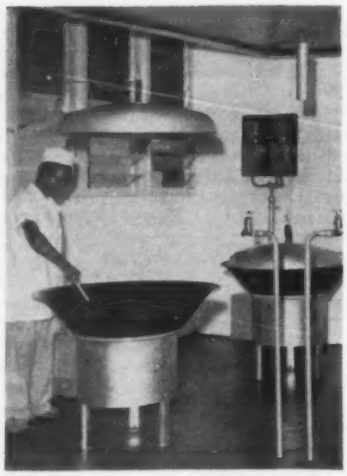
The keysets at the check-in counters are similar in appearance to those already in use in the S A S electronic seat availability system, but have facilities for keying-in baggage weight and the various categories of passenger.

The master sets at Load Control, which are also push-button devices, are used for the input of basic aircraft data and the output (either on a visual display or a printer) of load status and seat status reports together with load sheets and load messages for onward transmission to each destination of the flight concerned.

**Electric Chullahs Replace Charcoal Stoves**

An all-electric kitchen has been installed in the Ghurka Leave Centre, Fort Auchery, Batu Ferringhi, Penang, Federation of Malaya. Special facilities for Asian cooking are a feature of the kitchen, which supplies two main curry and rice meals a day to the hundred or so Ghurkas and their families spending a week's leave at the Centre.

Fort Auchery is a popular rest centre for the men and the 300 families of the eight Ghurka infantry battalions, as well as signals, transport companies and engineers, in Malaya. A disadvantage, however, had been the smoke from the wood and charcoal stoves, and the smell from the kerosene stoves or chullahs on which the Asian style cooking was done in huge, round-bottomed metal dishes known as kwalis.



*One of the four G E C chullahs installed in the all-electric kitchen at the Ghurka Leave Centre in Malaya*

The new kitchen has four electric chullahs devised by The General Electric Co Ltd of England, each capable of accommodating a 36 in (91 cm) diameter kwali in which rice for about 60 people can be cooked at one time. Each chullah has a 6 kW G E C radiant element, wound to fit the convex bottom of the kwali dish and controlled by a 3-heat switch. The aluminium frames and bodies of the chullahs are made to G E C specification by Diethelm & Co Ltd, Singapore.

So successful have these electric chullahs proved that the War Department is expected to specify them for any new army installation where Asian cooking is predominant.

In addition to the chullahs, the new kitchen is equipped with a fish fryer, a table-top cooker and two G E C single-oven ranges, each with a 7 cu ft (195 l) thermostatically-controlled oven and six large hotplates. The hot water installation comprises a 200 gallon (909 l) G E C water heater with a loading of 48 kW for rapid heating, a G E C 10 gallon (45·5 l) 9 kW water boiler and an instantaneous water boiler by Stotts of Oldham.

**British Computer Ordered for Australia**

A small but powerful electronic digital computer has been ordered from Ferranti Ltd in England by Imperial Chemical Industries of Australia and New Zealand Ltd (I C I A N Z) for use in their Central Research Laboratory in Melbourne.

The computer is the desk-sized Sirius of which a number are already installed and several more are on order in Great Britain. The I C I A N Z machine is expected to be installed during the first quarter of 1962. It will then be used for scientific and technical calculations and for the study of various problems connected with the chemical industry in Australia.

Installation will be carried out by engineers from the Melbourne office of Ferranti. Experience in operating and in training personnel will be gained by I C I A N Z on another Sirius to be installed in the Ferranti Melbourne Computer Centre later this year.

To handle the scale of problems involved, the overall capacity of the computer has been substantially increased by additional storage and extra facilities for rapid input and output of information. This expanded installation will cost about £A40 000, although the basic computer is considerably less.

The computer is a small transistorised general-purpose digital machine which can be installed by plugging into any ordinary electricity power point. Being a general-purpose machine, it is suitable for a wide variety of industrial, commercial, scientific and educational applications.

The machine has a number of special features. Decimal numbers are used throughout and can be displayed to the operator as such at any time. A simplified language for instructing or programming the machine, called Autocode, allows it to be used by people not specially trained as computer programmers. Thus the man with the problem can write his own programmes.

Facilities are provided to assure the user that the machine is functioning correctly. Automatic checking procedures are applied to the paper-tape input/output equipment and to the storage system while the computer is in operation. Any errors cause the machine to stop automatically.

Imperial Chemical Industries Ltd (I C I), the parent company in London, is a pioneer in the use and application of computers and already has a number of Ferranti machines installed.

**Price Reduction in Silicon-controlled Rectifiers**

Following recent reductions in the prices of their silicon diodes, Westinghouse Brake and Signal Co Ltd have now announced substantial reductions, amounting in some cases to 50 per cent, in the prices of 'Trinistor' silicon controlled rectifiers.

In addition, a new range of 'Trinistors', type CS32, with current ratings of 16 A and voltage ratings of 25 to 400 V, has been introduced and supplements the existing CS31 25 A range.

It is planned that other sizes of 'Trinistors', both larger and smaller, will be announced later in the year and these, together with existing types, will provide a complete range of silicon controlled rectifiers for industry.

**Birlec Furnaces to be made in Australia**

An agreement has been made between A E I-Birlec Ltd, of Birmingham, and Major Electric Furnaces Pty Ltd, of Melbourne, Australia, for the setting up in Melbourne of a new company to be known as Birlec-Major Pty Ltd, with offices in Chesterville Road, Moorabbin, Melbourne.

Birlec-Major Pty Ltd will manufacture every type of electric and gas-fired furnace for heat-treatment and melting processes at present built by Birlec and their associate companies in the U K. In addition to serving the Australian market, the new

company intends to market its products in New Zealand and S E Asia.

Since 1952 Birlec furnaces have been manufactured under licence by Major Electric Furnaces Pty Ltd and are installed in most Australian industries. However, this agreement now comes to an end, and the formation of the new company will greatly strengthen the technical and specialist design services available to Australian furnace users.

**Fibreglass Price Reduction**

Price reductions in certain continuous filament process products have recently been announced by Fibreglass Ltd of St Helens, Lancashire. The latest announcement affects the price list for Fibreglass C F yarns manufactured from E (alkali-free) glass and covers a wide range, but mainly in the heavier yarn counts. This will be of particular interest to weavers and braiders of glass yarns and consequently the users of glass electrical tapes, industrial cloths, decoratives and woven plastics reinforcement materials.

Other price changes notified earlier covered reductions to the full range of Fibreglass plastics reinforcement materials in high performance E composition glass, including chopped strand mat, needled mat, chopped strand filaments and rovings.

Fibreglass Ltd expect that these reductions will help to widen substantially the applications for reinforced plastics throughout industry.

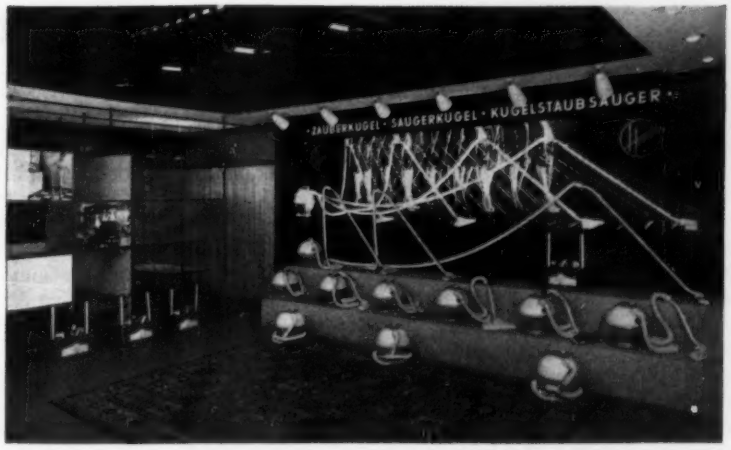
**Two Leading Firms Get Together**

The General Electric Co Ltd of England and Richardsons, Westgarth & Co Ltd recently announced that they have decided to pool their resources for the design, development, sales and manufacture of heavy electricity generating and industrial power plant. The object of this arrangement is to secure an increase in their share of the home and export markets and at the same time to make the maximum possible use of their combined technical resources and production facilities.

The manufacture of all plant covered (steam turbines, turbo-type alternators, blowers, compressors and exhausters) will be shared and initially based on current G E C designs. Richardsons, Westgarth will concentrate on the design of industrial power plant with the object of supplementing existing G E C designs and widening the range of plant offered.

Richardsons, Westgarth will continue to be responsible for the sale and manufacture of condensing and feed heating plant, rotary water strainers, evaporators, and shell boilers to its own design and land water-tube boilers to Foster Wheeler design, as well as its wide range of marine engineering activities.

The two companies therefore are now jointly in a position to build and equip, electrically and mechanically, complete modern power stations from within their own resources.




*The Hoover German Company, Hoover GmbH, occupied a large stand at the Cologne Fair held in February this year. On the stand particular emphasis was given to the Hoover 'Constellation' vacuum cleaner. The machines attracted a lot of attention, both in display and demonstration, and was one of the items in the local television programme report on the Fair*

**Diesel Generating Plant ordered for India**

W. H. Allen Sons & Co Ltd, of Bedford, have received an order from the Lummus Company covering the supply of a 750 kW diesel-alternator set for a synthetic rubber plant which is being built for synthetics and chemicals at Bareilly, India, the complete installation of which is being handled by The Lummus Company.

The unit consists of a 12-cylinder (V-form) pressure-charged Allen type VBS12C engine, running at 750 rev/min and driving a 750 kW Allen alternator suitable for operation on a 3 300 V, 3-phase, 50 c/s supply, at 0·8 power factor. The set is to be supplied complete with radiator, air compressors and a control panel for alternator and exciter and will incorporate auto-starting equipment for the diesel engine; with the exception of the panel, all equipment will be mounted on a skid-type baseplate.

Two 3 000 kW steam turboalternator sets are also to be installed in this factory and the diesel set will initially supply power for the starting up of the turboalternators, and afterwards serving for standby duty.

*This control board, the longest ever manufactured by A E I, is one of 15 made for the U S S R*

**Largest A E I Control Board for Russia**

The largest control board ever made in the Motor and Control Gear Division of Associated Electrical Industries Ltd was shipped recently to Russia. The board is over 61 feet (18·6 m) long and includes a 13 foot (4 m) laminated plastic mimic control diagram at its centre, fully coloured to indicate the various flow paths.

The board is one of 15 which are being supplied by A E I to Simon Handling Engineers Ltd, a member of the Rustyfa Consortium, for a Russian tyre factory. It will control motors used to drive plant for the manufacture of rubber pellets from incoming rubber slabs and their transfer to the main storage bins. It will also control the equipment used for transferring these pellets from the main storage bins to the process bins at each mixing station.

This control board, together with others included in the same order, will be located in a central control room from which the various operations of the plant are controlled.

**Hoover on the High Seas**

Among the many amenities provided on some of the world's newest and most luxurious ships are several items of Hoover equipment.

For example, the new P & O liner *Oriana*,* is equipped with 94 Hoover suction cleaners, 19 spin-dryers and 8 washing machines. More recently the French Line has ordered from the French Hoover company 160 British-made Hoover cleaners for the new French Line ship *France*, which was launched last year by Madame de Gaulle.

* THE BEAMA JOURNAL, 68, No 1, pp 26-27

# Elland Power Station

A NEW power station of 180 MW capacity at Elland, in Yorkshire, was officially opened at the end of April. The following is a brief description of its main features.

As the station is situated on low ground which is liable to flooding, the whole site has been built up to a height above the highest expected flood-water level of the River Calder which runs alongside the site. Also, as the station is located in a comparatively narrow valley, particular attention was paid to the relative siting of the cooling towers and chimney to avoid any nuisance from down-draught. The chimney itself was built to a height of 400 feet (122 m)—an exceptional height for a station of this size.

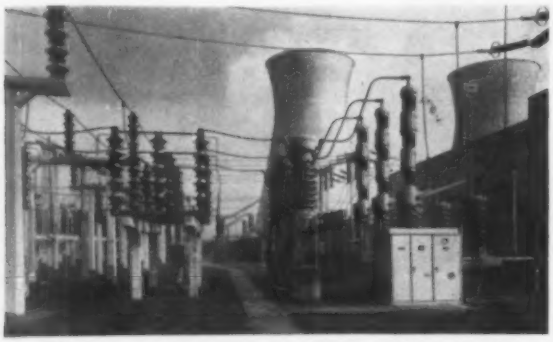
**Main Buildings**

A most compact and economic design was evolved for this station. To overcome the problems of building on a subsoil consisting of gravel over clay, a box structure was used for the main foundations, with specially strengthened vertical sections to support the heavy plant. The spaces left in the box between the vertical sections are used for cable runs. Above this 'sub-basement' is the basement level some 7 feet (2·13 m) below ground level. From basement level to operating floor level, the height is only 20 feet (6·09 m)—a remarkably small height compared with most power stations, and this resulted in a considerable reduction in building costs.

Steel framing, clad with brick to a height of 14 feet (4·27 m) above ground level and finished above in aluminium sheeting, has been used for the turbine house structure.

Adjoining the turbine house is the boiler house. This has an operating floor level some 10 feet (3·05 m) above that of the turbine house, although the basement level is the same for both buildings. Again, steel framing has been used, but in this case the cladding is corrugated protected steel sheeting.

As the station is operated on the unit principle of one turboalternator associated with one boiler, there are three boilers, each of 550 000 lb (249 476 kg) per hour evaporative capacity. Between the turbine and boiler houses is an annexe in which, at basement level, the boiler feed pumps are installed. Combined machine and boiler control centres are also located in this annexe at turbine house operating floor level, as are also the auxiliary switchgear control panels. High level de-aeration is used, the de-aerators being mounted in the annexe some 37 feet (11·3 m) above the turbine house operating floor, and water storage tanks are mounted at boiler house roof level.



*The 132 kV switching compound at the Elland Sub-Station*

The south side of the boiler house contains the coal bunkers, each of which has a capacity of 650 tons (660 431 kg), and directly below them are the pulverising mills in the basement.

A feature of these buildings is that they have been designed so that rain water can run from the roofs and down the sides of the walls; it is not collected in guttering until some 14 ft (4·27 m) above the ground in the case of the turbine house and 24 ft (7·32 m) for the boiler house.

In the whole design of the boiler and turbine house, the object has been to produce a very compact arrangement and to reduce cost to a minimum compatible with facilities for plant maintenance and architectural appearance.

Coal is brought in from the South Yorkshire coalfield, mainly by rail, but provision has been made for road-borne supplies as necessary, and approximately 16 000 tons (16 256 tonne) a week come into the station. Although the coal is deep-mined, it is of low-grade quality, with an average calorific value varying between 9 200 and 10 000 B t u (2 338 to 2 520 kcal) per lb, and with ash and moisture contents up to 27 per cent and 14 per cent respectively. Average moisture, however, is about 8 per cent.

**Boiler Plant**

Elland power station is somewhat unusual in that two different makes of boiler have been installed. No 1 boiler is of the two-drum, natural circulation type giving 550 000 lb (249 476 kg) of steam per hour at a pressure of 950 lb/in$^2$ (66·8 kg/cm$^2$) and 925 deg F (496 deg C) at the boiler stop valve. Nos 2 and 3 boilers are of the single-drum natural circulation type for the same conditions of operation as No 1 boiler.

No 1 boiler is a corner-fired unit fed by four vertical type roller and table pulverising mills. The coal enters these mills from the bunker downcoming pipes via variable speed feeders which regulate the quantity of fuel entering the furnace.

From the mills, the finely ground coal is carried by an air stream through pipes into the burners mounted at the corners of the boiler furnace. By tilting the burners the heat distribution in the furnace can be varied, and this in turn affects the amount of heat passing through the walls of the superheater tubes. Thus some degree of control of superheat can be attained by varying the tilt. In addition, automatic spray-type desuperheaters are provided. There are in all 16 burners, four to each corner.

After passing through the superheater banks, which are mounted in the horizontal pass at the top of the furnace, the gases descend through a vertical pass between the coal bunkers and the combustion chamber, where the economiser is located. They then travel through two large ducts below the boiler operating floor to a vertical pass outside the building containing the air heaters. Finally they enter the precipitator block, where the dust is removed, and then are transferred to the chimney via the two induced-draught fans which are located in the open.

Two forced-draught fans for the boiler are mounted above the bunker house and draw warm air from the top of the boiler house.

For lighting up, oil burners are used, firing into the boiler from the turbine house side. There are four oil burners in No 1 boiler, and ten in Nos 2 and 3 respectively.

**Nos 2 and 3 Boilers**

Although these have the same output and steam conditions as No 1 boiler, there are many significant points of difference. There are five pulverising mills for each boiler, and these are of an entirely different type from those used on No 1. They are constant-speed horizontal mills consisting of a beater mill, followed by an attrition stage and a final fan stage, all running at near synchronous speed on the same shaft. As the mills were originally of American design, a gear box giving a 5 : 6 step-up ratio has been introduced between the induction motor and the mill assembly, which is split on a horizontal flange for easy maintenance.

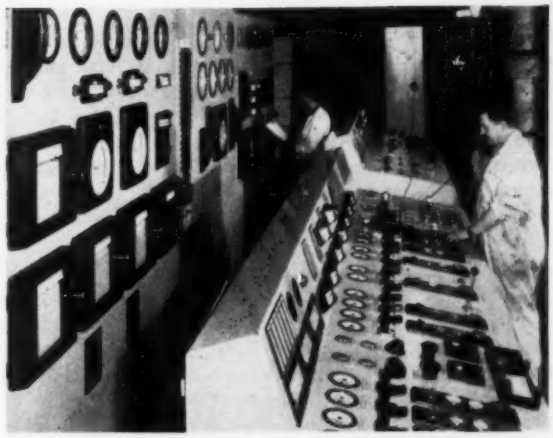
The fuel is blown into the boiler furnaces from burners in the front furnace wall which in this case is on the side of each boiler remote from the turbine house. The superheaters and economiser are located in the horizontal and downward passes which lie between the combustion chamber and the turbine house, and the gas ducts to the air heaters pass on each side of the combustion chamber below operating floor level.

As the burners are fixed, the temperature of the superheated steam is controlled by automatically operated dampers regulating the flow of the flue gases across the primary superheater, and in addition there are automatically operated spray-type desuperheaters.

In common with No 1 boiler, Nos 2 and 3 have two forced-draught and two induced-draught fans, and each of the three boilers has a fully automatic control system operating from the combined generator and boiler control panels located in the turbine room at operating floor level.

**Turboalternators**

The three turboalternators are all of A E I manufacture and have a continuous maximum rating of 60 MW each. Steam conditions at the turbine stop valve are 900 lb/in$^2$ (63·3 kg/cm$^2$) at 900 deg F (482 deg C), and the vacuum in the condenser is 28·7 in (729 cm) Hg. Five stages of feed heating are used in the feed water system, the steam for this purpose being bled off at suitable points along the turbine cylinders. A 'close-coupled' design has been used, and the two-cylinder machines have only three bearings. This arrangement reduces the overall length of the set. The blading is of the impulse type, and there



*Each boiler and turboalternator set is controlled as a unit from the control centre. This photograph shows the control console for No 2 unit*

are 19 stages in the high-pressure cylinder and six stages on each side of the double-flow low-pressure cylinder.

Below the low-pressure cylinder are twin condensers of the three-pass type. These contain 11 460 tubes to give a surface cooling area of some 60 000 ft$^2$ (5 574 m$^2$). The tubes are 20 ft (6·1 m) long and are expanded into the end plates, the expansion being taken up by a flexible joint in the shell.

Hydrogen cooling at 15 lb/in$^2$ (1·05 kg/cm$^2$) is in the alternator, which has gas-to-water coolers located inside the stator casing. The gas is circulated by integral fans built on the alternator shaft.

Direct current for the alternator rotor is provided by an air-cooled exciter directly driven at 3 000 rev/min from the alternator shaft. The air cooling is an open-circuit system, and clean air is provided through film filters positioned below the exciter in the basement.

A c is generated at 11·8 kV and is taken by solid copper connections through ducts to the generator transformer, rated at 72 MVA, in the transformer annexe outside the turbine house.

The auxiliary plant associated with each set is largely packed under the alternator, the oil tank being supported on a cantilever structure on the side of the alternator supporting block and remote from the turbine.

**Feed Water System**

From the condenser, the water is extracted by two 100 per cent duty extraction pumps, one of which is used as a stand-by unit.

Each has a capacity of 750 gallons (3410 l) per minute. The feed water then passes through three low-pressure heaters, of which the third is a high-level combined feed-water heater and de-aerator. From the de-aerator the water passes to the inlet of the feed pumps. Again there are two of these, each capable of 100 per cent duty. They have a capacity of 650 000 lb (294 835 kg) of water per hour, and discharge at a pressure of 1 205 lb/in$^2$ (84·7 kg/cm$^2$) to the high-pressure feed heaters. When the water enters the boiler it has reached a temperature of 385 deg F (196 deg C).

The feed pumps are driven by 33 kV motors developing 1 400 h p each.

**Switchgear and Transformers**

Auxiliary switchgear is housed in an annexe running along the south side of the station. All the large motors driving the feed water pumps, the circulating water and tower pumps, the pulverising mills and the forced draught and induced draught fans are fed at 3·3 kV and controlled by air-break switchgear. The smaller auxiliary motors are fed at 415 volts.

North of the station is the 132 kV outdoor switching station which connects the station to the grid. The switchgear at this station is of the air-blast type rated at 3 500 MVA. Layout of the switching station is conventional, with double busbars, bus section isolators and bus coupler. Provision is being made for an extension of the 132 kV switching station and a site to the west of the power station has been selected for a 275 kV switching station which will be necessary at a later date.

Each generator has its own outdoor transformer, with a step-up ratio of 11·8 kV to 132 kV, and its own unit transformer of 6 MVA, connected solidly to the tail ends of the alternator. These unit transformers have a voltage ratio of 11·8 kV to 3·3 kV and supply all the auxiliaries for each set.

For starting and emergency purposes, there are two station transformers rated at 7·5 MVA which take supplies from the 132 kV grid system and feed the auxiliary power system at 3·3 kV.

**Control**

Each boiler and turboalternator combination is controlled as a unit from a control centre located in the annexe between the boiler house and the turbine house. These control centres are open to the turbine house, but provided with an acoustic hood which gives a degree of sound-proofing. Units can be operated on 'full automatic', when the quantity of air entering the furnace, the amount of coal being consumed, and the steam pressure and temperature are automatically regulated to suit the load on the turboalternator and to maintain the efficiency of the unit as a whole at its maximum.

Overall control of the station is carried out in a control room located in the administrative block and adjacent to the turbine room. Double-glazed windows in this room allow the control engineer to look into the turbine room, and there is also an external view from windows looking out to the north over the 132 kV switching compound.

**Contractors and Equipment**

Among the main contractors and the principal sub-contractors were the following BEAMA member-firms:

Allen West & Co Ltd—control gear; A E I (Manchester) Ltd—turboalternators, 3·3 kV switchgear, boiler feed pump motors; Babcock & Wilcox Ltd—ash handling plant; British Vacuum Cleaner and Engineering Co Ltd—vacuum cleaning plant; Brookhirst Igranic Ltd—limit and auxiliary switches; Chloride Batteries Ltd—batteries and rectifiers; Crompton Parkinson Ltd—main auxiliary and control cables, station transformers, motors; Denis Ferranti & Co Ltd—unit auxiliary transformer; Drysdale & Co Ltd—extraction, river and cooling tower pumps; Electric Construction Co Ltd—river and cooling tower pump motors; English Electric Co Ltd—132 kV and 415 V switchgear; Ferranti Ltd—generator transformers; G. & J. Weir Ltd—air ejectors; Laurence, Scott & Electromotors Ltd—i d and f d fan motors; Mather & Platt Ltd—distilled water pumps; Mirrlees Watson Ltd—oil pumps; Rockweld Ltd—welding equipment; Standard Telephones & Cables Ltd—communication and internal telephones; Stewarts & Lloyds Ltd—boiler tubing, h p pipework; Sturtevant Engineering Co Ltd—dust extraction plant; Wallace and Tiernan Ltd—chlorination plant; Worthington-Simpson Ltd—air compressors; Yorkshire Imperial Metals Ltd—condenser tubes; Yorkshire Electric Transformer Co Ltd—unit and auxiliary transformers.

# The 1961 BEPC

THE Thirteenth British Electrical Power Convention takes place this year from June 12 to 15 at Eastbourne, on the south coast of England.

The office of President of the Convention is filled in alternate years by leading personalities in the manufacturing industry and the supply industry respectively, and this year's President is Sir John Pickles, B SC, M I E E, Chairman of the South of Scotland Electricity Board. He will deliver the Presidential Address on the Convention theme 'Electricity in the Prosperity and Welfare of the Nation' on Monday afternoon, June 12. The speakers and their subjects at the business sessions on the following days are:

**The British Electricity Transmission System**

Sir Christopher Hinton, K B E, F R S, Chairman of the Central Electricity Generating Board.

**Some Aspects of Efficiency and Economy in Distribution**

Mr R. R. B. Brown, B A, B SC, Chairman of the Southern Electricity Board.

**The Electrical Power Industry in Canada**

Dr A. E. Grauer, B A, PH D, LL D, Chairman of the British Columbia Electric Co Ltd, Vancouver, Canada.

**British Electrical Manufacture in the National Economy**

Mr S. F. Steward, C B E, M I PROD E, Director of the British Electrical and Allied Manufacturers' Association.

**Electrical Forum**

Question Master: Sir John Pickles.

Members of the Panel:

Mr F. H. S. Brown, C B E, B SC, M I MECH E, M I E E, Deputy Chairman, Central Electricity Generating Board.

Mr Sebastian Z. de Ferranti, Managing Director, Ferranti Ltd.

Mr A. A. Fulton, C B E, F R S E, B SC, M I C E, M I MECH E, M I E E, General Manager, North of Scotland Hydro-Electric Board.

Sir Robertson King, K B E, COMP I E E, M INST F, Chairman of the Electricity Council.

At the Annual Dinner on the evening of Wednesday, June 14, the principal guest will be the Rt Hon John S. Maclay, C M G, M P, Secretary of State for Scotland.

# Electrical Equipment on a Large Floating Crane

AN interesting contract recently carried out by the General Electric Co Ltd of England was the construction and supply of the main electric power and propulsion equipment for a 60-ton twin-screw floating crane for the Mersey Docks and Harbour Board of Liverpool.

This was the latest of a number of similar floating cranes, and it was specially developed to meet the difficult conditions prevailing at the Liverpool Docks. These include the need for a high degree of manœuvrability because of the confined areas in which it has to operate, and a higher speed than usual—10½ knots—to enable it to cope with the fast tidal currents in the main channel.

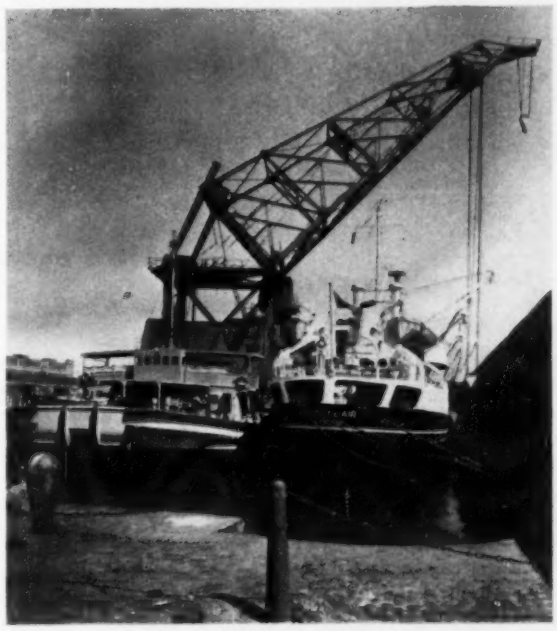
'Samson' (as the crane has been named) has an overall length of 183 ft (55·8 m) and a moulded breadth of 56 ft (17 m), and to offset the very high windage areas of the main structure the vessel is fitted with a specially shaped hull.

The main hoist of the crane has a capacity of 60 tons (60 963 kg) up to a maximum radius of 98 ft 8 in (30 m), while that of the auxiliary hoist is 25 tons (25 401 kg) up to a maximum radius of 93 ft 8 in (28·5 m). Operating speeds of the hoists are 15 ft (4·6 m) per minute and 55 ft (16·8 m) per minute respectively. A power-driven travelling-ballast weight counterbalances the loads being lifted. Slewing through 360° can be carried out in four minutes with a 60-ton (60 963 kg) load on the hook.

To assist in manœuvring the vessel in the confined waters of the docks and alongside ships, a bow-steering pump is fitted. This is an axial-flow type pump located in a duct having outlets on the port and starboard sides of the craft. The pump, which is driven by a 200 h p electric motor, can expel water from either outlet, exerting a maximum thrust of approximately 2 tons (2 032 kg). Additional manœuvrability is provided by the widely-spaced twin screws and rudders.

**Power Equipment**

Each of the two 900 h p, 600 rev/min diesel engines is connected through an articulated flexible coupling to a main and an auxiliary generator. The rating of each main d c generator is 330 kW at 440 V and of each auxiliary d c generator 300 kW at 220 V. Power for the propulsion motors is obtained from the main generators, and for all other services from the auxiliary machines. The rating of the auxiliary generators is such that one machine is capable of supplying the entire crane and auxiliary service loads. A further two 30 kW 220 V d c generators, each driven by a diesel engine, provide power for the essential services when the 360 kW auxiliary generators are not running. Paralleling of all the 220 V generators is possible, thus preventing interruption of these services when changing the source of supply.



*A general view of the 60-ton floating crane*

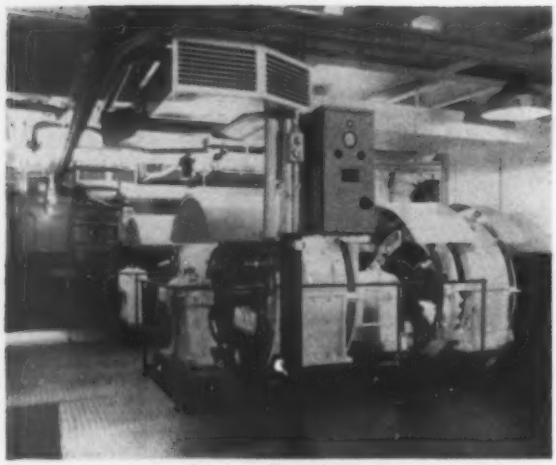
**Propulsion Motors**

The screws are direct-coupled to 400 h p motors which are mechanically and electrically independent, separate Ward Leonard speed-control systems being employed for each motor. Four steps of speed in either direction are provided for each motor by variation of the appropriate generator field excitation. Relays automatically reduce this excitation if attempts are made to increase the load on the propulsion motors too rapidly. If conditions are such as to cause a sustained overload, then relays operate to remove the excitation completely.

**Hoisting and Derrick Motors**

Power for the 130 h p crane hoists and the 75 h p derrick motor is obtained from a 107 kW Ward Leonard set, which in turn is supplied from the 220 V auxiliary generator system. A 3-position rotary-type selector switch enables a choice of either of the hoists or the derrick motor to be made, the speed of the particular motor selected being controlled by a 9-notch controller which varies the separately-excited and self-excited fields of the Ward Leonard generator, with the additional facility in the case of the crane hoist motors of field weakening on notch 9.

The circuit is so arranged that in the event of an overload or the tripping of a limit switch, the controller has to be returned to the first notch before the particular



*The port main propulsion and auxiliary generators. Mounted in tandem, the generators are driven from a common diesel engine*

motor can be re-energised. When loads are being lowered, regenerative braking is employed, and if the auxiliary system is incapable of absorbing the regenerated power, ballast resistors are automatically introduced into the circuit.

**Slewing and Ballast Motors**

Series-wound slewing and ballast motors are employed and these are supplied direct from the auxiliary generator system. The 45 h p slewing motor is energised through a 6-notch controller and a contactor starter. The latter is fitted with a timing device to prevent the motor being accelerated too rapidly by the operator, who nevertheless retains full control over the final speed of slewing. A diverter resistor on the first two notches permits creep-speed slewing.

Speed and direction of the 20 h p travelling-ballast motor are varied by a 7-notch controller, and a position indicator working on the potentiometer principle shows the location of the ballast trucks. Warning lights indicate if the forward or backward limit switches trip. Creep-speed operation is obtained by shunting the motor armature with diverter resistors.

**Control Cabin**

All controls for the operator are housed in a cabin at the front of the crane superstructure. Two consoles, one on each side of the operator's seat, contain warning lights, pushbuttons, ammeters and other indicating instruments. One of the consoles also carries the slewing-motor controller and the other the travelling-ballast controller.

Immediately in front of the operator is the 3-position rotary switch for selecting either of the hoists or the derrick motor. Adjacent to this switch is the lever-type 9-notch controller for speed variation of the selected motor. Interlocks are fitted to ensure that the selector switch can be operated only when the controller is in the 'off' position. Pushbuttons are also provided to enable the operator to override the top limit switches of either of the hoists or the derrick motor, and red warning lamps show when this has been done.

The structural and mechanical parts of the crane were manufactured by Cowans Sheldon and Co Ltd, and the electrical equipment was supplied by the G E C to the order of Charters of Glasgow.

## Another Unusual Substation

AN unusual substation in Scotland was described in a recent issue of THE BEAMA JOURNAL*. There is another equally interesting one in the heart of London in the district of Soho.

Soho Square is like most other squares in London, with a neat garden in its centre which in the fine weather attracts many Londoners who eat their lunch there, read, or merely gossip. In the middle of the garden is a beautiful Tudor-style, black and white house. Quite small, it could be anything from a refreshment kiosk to a gardener's lodge. In fact, it is none of these things. Its main purpose is to serve as camouflage for a large ventilating shaft for the automatic substation that lies underneath.

The substation itself is built under a large section of the garden. The site was excavated and the substation installed in 1926; it was extended in 1927, and in 1928/9 the ventilating shaft was incorporated. This gave rise to the black and white house which, although of modern construction, was built with the original timbers dating back to the time of Elizabeth I.

In those days the garden was the property of the owners of the large houses round the square and the present design is still largely as they laid it out. The garden was acquired by the Westminster City Council at the end of the last war.

The square itself is rich with historical association. Its first resident was the Duke of Monmouth, son of Charles II and Lucy Walters. George II lived there when he was Prince of Wales, and silk knee breeches, crinolines and powdered wigs were an everyday sight there in the eighteenth century.

Of the many Londoners and visitors to the capital, few can have suspected that a substation throbs beneath their feet, with its 11 kV switchgear, two motor converters of 750 kW each, two rotary converters each 150 kW, switchgear for these, and a standard 500 kVA transformer which supplies a c to the area around the Square.

*THE BEAMA JOURNAL, 67, No 4, p 136

# Trends for the Future at the Ideal Home Exhibition

THE annual Ideal Home Exhibition, organised every year at Olympia, London, by the *Daily Mail*, one of Britain's leading newspapers, is becoming increasingly important as the stage on which many new domestic electrical appliances make their first appearance before the world.

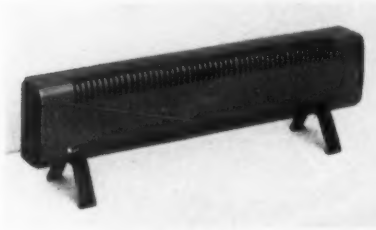
The British domestic electrical appliance industry is energetically expanding in all directions, and last year it sent from Britain to the markets of the world £33 million worth of its products. Visitors to the International Household Goods and Hardware Fair at Cologne in February last who saw the British stands in Hall II will need no reminder of the great interest taken by buyers from all over Europe in the British equipment displayed there.

The principal trends revealed at the Ideal Home Exhibition can be summed up as still higher efficiency over a wider range of electrical applications, with increasingly attractive presentation and prices generally at a somewhat lower level—all adding up to better value for money than ever before.

**The Trend to 'Automation'**

In the field of what might be termed the basic electrical equipment of the home—cookers, refrigerators, suction cleaners, washing machines, fires, and heaters—the range of models, sizes and styles is wider than ever, and a striking feature is the increasing trend towards what is popularly called 'automation'.

Cookers equipped with automatic time-controlled ovens are now offered by practically every maker, but on at least one new model by English Electric the principle has been extended to one of the boiling rings, so that even a saucepan of milk can be left on indefinitely with the certain knowledge that it will not boil over.



*Among the many types of heaters shown by Dimplex Ltd was this skirting board model, available as shown or without feet for mounting direct on the wall or skirting board. The loading is 300 W*

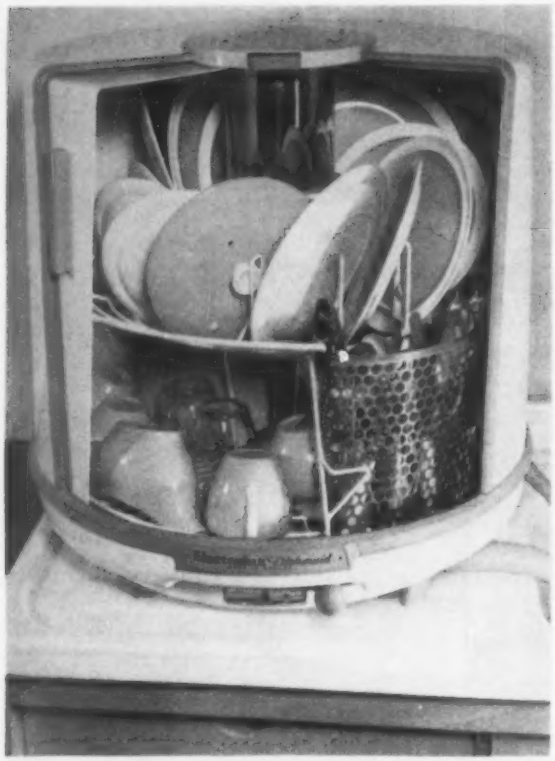
The technique of 'rotisserie' cooking—roasting on a revolving spit—is fast coming back into popularity, and an increasing number of cookers now incorporate facilities for this time-honoured method of cooking. Perhaps one of the most versatile adaptations is the G E C 'Treasure' cooker, on which the pan of the eye-level grill can be easily and quickly removed and replaced by a rotary spit which is available as an optional extra.

'Automation' in the field of washing machines is exemplified by the 'dial-a-fabric' feature of the English Electric 'Liberator' introduced last year, in which the 'programming' of the washing cycle is automatically effected by setting the dial to the nature of the fabric to be washed. A further development is introduced this year by Hoover with their 'Keymatic' washing machine, in which the washing cycle is entirely controlled by inserting into a slot a small plastic tablet which provides eight different washing programmes.

*The Gramophone Co Ltd ('His Master's Voice') has recently extended its range of domestic electrical appliances. This 'Polar Star' refrigerator, available in two sizes, has several novel features, including an external temperature setting dial*

Refrigerators do not readily lend themselves—nor do they normally need—an advanced degree of 'automation', but on an increasing number of models the usually troublesome process of defrosting has been made either almost or completely automatic—the former by means of a 'defrost' button which merely has to be pressed and normal operation is resumed as soon as defrosting is complete, and the latter by a built-in device which carries out defrosting entirely automatically. The use of magnetic door closures is increasing, and so is the trend towards colour. English Electric, for example, are now offering their 'Slimline' range in six highly attractive colours.

The increasing popularity of frozen packaged foods has been catered for by two new design features on many models: a large freezer compartment to hold a considerable quantity of such packages, and provision for maintaining this at a temperature of zero deg F (-17·8 deg C) while keeping the rest of the cabinet at normal storage temperatures in the range of 40 to 45 deg F (4·4 to 7·2 deg C).



*The new Electrolux 'Dishmaid' dishwasher is attractively styled in white and primrose yellow, and designed on very compact lines*

Suction cleaners produced no startling innovations this year comparable with the revolutionary Parnall 'Ten-ten' and the Hoover 'Constellation' of other years. Rather there have been detail improvements in efficiency and convenience, as exemplified by the Electrolux Model 65 which performs all the normal cleaning operations with only two versatile tools, and the 'Hooverette', described as two cleaners in one.

**New Dishwashing Machines**

Though not as yet regarded as such basic appliances as washing machines, there are unmistakable signs of an increasing demand for dishwashers to remove yet another item of domestic drudgery. A newcomer this year to the range of such machines is the Electrolux 'Dishmaid' which embodies a variant of the usual technique in that the water jets are stationary while the crockery revolves. (Most dishwashers operate the other way round, the crockery remaining stationary while the water jets revolve.) This has resulted in a certain simplification of construction, increased efficiency, and a lower price than some other machines.

It is designed as a compact, portable and easily installed machine operating on any normal hot water system which provides water at not less than 120 deg F (48·9 deg C). Having no heater, its running cost is very low and it requires no fixed plumbing.

The 'Dishmaid' has a circular dish rack which is rotated by a built-in double-insulated a c motor rated at 75 W. A centrifugal pump forces hot water from the hot water tap through a series of five tubes, one spraying from the top, one from the bottom and three from the sides of the cabinet. As the dish rack rotates, all the dirty crockery and cutlery is sprayed thoroughly from top, bottom and sides from each tube in turn. A simple draining device carries away the dirty water through the outlet hose to the sink.

Other features include a switch which cuts out the motor automatically if the door is accidentally opened while the machine is in use.

Another prominent exhibit in this field (although not a new introduction this year) was the 'Dishmaster' dish-washing machine by Kenwood Manufacturing (Woking) Ltd, who also featured their 'Wastemaster' garbage disposal unit—another example of the widening field of electrical application in the kitchen.

**A Completely Automatic Washing Machine**

Reference has already been made briefly to the new Hoover 'Keymatic' washing machine, but its advanced technical design merits a fuller description.

Its name is derived from the 'Keyplate'—a small square plate in moulded plastic with eight available washing programmes printed on its eight edges.

For the best washing results it is essential to have the correct combination of water temperature, washing action and time. The 'Keymatic' combines these in exactly the right manner, according to the programme selected on the Keyplate. The 'Keymatic' will fill the tub automatically from the taps, selecting either hot, cold, or a mixture of hot and cold water; heat the water if the tap water is not hot enough; choose the type of washing action; wash for the correct length of time for the fabric; give three rinses of gradually reducing temperature, down to a cold rinse which is ideal for conditioning fabrics, and then finish with a spin dry period. During the washing cycle a visual indicator shows the progress of the machine through its selected cycle.

*The plastic moulded Keyplate of the Hoover Keymatic washing machine, which selects any one of eight different washing programmes. The slots around the edges are 'read' by the sensing contacts of the control switch and thus determine the programme*

The 'Keymatic' takes 8 lb (3·6 kg) dry weight of washing and, using the hot water supply, the whole completely automatic cycle can be completed in less than half an hour, depending on the temperature of the hot water supply and the nature of the fabric.

*The new Hoover Keymatic washing machine. Noteworthy features are the inclined drum for easy loading and the drop-down door which also forms a convenient support for the clothes receptacle*

The washing operation for delicate fabrics is effected by the tumbling action of the rotating drum, which revolves at 47 rev/min. Where a more vigorous washing action is required, the pulsator mounted within the drum on the same axis revolves simultaneously but in the opposite direction at 720 rev/min. Both the drum and pulsator are belt-driven through clutches by a $\frac{1}{3}$ h p capacitor-start motor, and an ingenious feature is that spin drying is achieved by revolving the drum at pulsator speed—720 rev/min—merely by reversing the motor and the automatic action of the clutches.

**Printed Circuits in the Selector Switch**

The selector switch which is actuated by the Keyplate has 36 positions and incorporates a series of combined time-, thermostat-, and cam-operated switches and printed circuits. The water intake valves are solenoid operated and so controlled that the incoming water is kept just below the required washing temperature and brought up to the correct temperature by the built-in 3 kW immersion heater.

An effective brake, with a braking time from spinning with a full load to rest of ten seconds, is automatically applied at the end of the cycle or if the door is opened during operation. Another safety device is an out-of-balance trip which opens the main switch if the clothes are so badly distributed as to cause an excessive out-of-balance load.

The 'Keymatic' is available in standard versions for a c supplies of 200 to 225 and 230 to 250 V, 40 to 60 c/s, but a special version is also supplied for operation on 380 V to suit the conditions in Sweden and Western Germany.

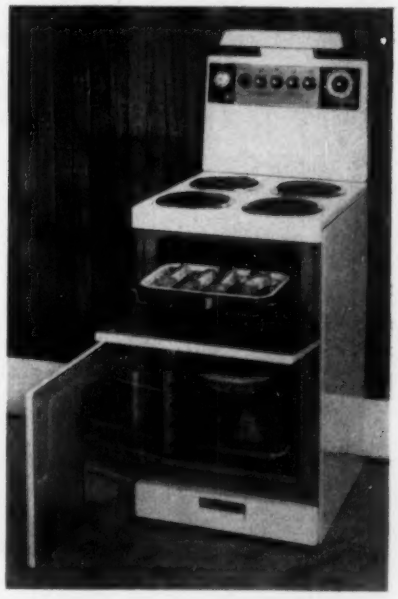
**A New Trend in Cooker Design**

The new English Electric cooker mentioned earlier has many special features as well as the automatic safety device on one of the boiling rings.

It is in fact Britain's first plinth-type cooker with two ovens one above the other. This makes a particularly compact double-oven cooker, and it measures only 21 in (53·3 cm) wide, 25 in (63·5 cm) deep and 36 in (91·4 cm) high.

With the two ovens, a large variety of dishes can be cooked at the same time. The lower oven, which will take a 35 lb (16 kg) turkey, has an inner glass door and an interior light. It is thermostatically controlled with a temperature range from 150 to 550 deg F (65·6 to 287·8 deg C) and has an automatic timer.

The top oven has a pre-set temperature of 300 deg F (149 deg C), is fitted with a spring-loaded drop-down door, and can also be controlled by the automatic timer. This oven can be used as a grill; as an oven for slow cooking, and as a hot cupboard. The large grill operates at either red or black heat; and the grill pan has a specially designed aluminium plate on the bottom to prevent spitting and smoking. A non-tilt shelf, which can be adjusted to three different positions for baking, also forms a rest for the grill-pan when it is pulled out.



*Another newcomer at the Exhibition was this English Electric double-oven cooker, which sets a new trend by placing the ovens one above the other instead of side by side*

The hob has four 7 in (17·8 cm) 'Veeline' hotplates with chromium-plated steel trims and deep vitreous enamel spillage bowls underneath. These hotplates have a hinged element which can be lifted to an almost vertical position to allow the bowl to be cleaned without removal.

The 'sensing' disc in the centre of one of the back hotplates makes boiling over almost an impossibility by automatically holding the temperature of the plate at a constant heat which can be regulated exactly.

The 15 in (38 cm) high splashplate is fitted with a shaded tubular hob-light and the control panel at the top—well out of the reach of children. The bottom drawer provides storage for the grill pan and other items.

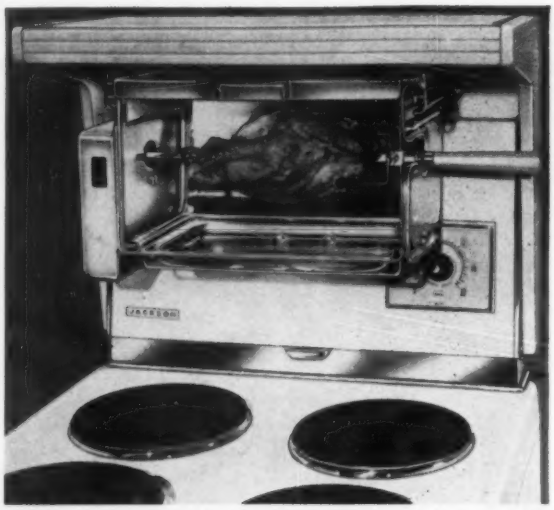
**The Versatility of Electric Heating**

Fires, radiators and heaters of all kinds were well represented on many stands, and an interesting new idea was one of the range of fires by Berrys Electric Magicoal Ltd with a disappearing element which retracts when the fire is switched off.

An extension of the use of electricity in the heating field was its application to the ignition of solid fuel fires, as exemplified by the new G E C hot-air firelighter. This operates on the same principle as an electric hair drier and will ignite a bituminous coal fire in an open grate in 1½ to 4 minutes. Inside the firelighter is an intertwined electric element passing through an extra tough heat-resisting porcelain former; this is mounted in a tube and a jet of air is blown over it by an impeller. The air rapidly reaches a temperature of 700 deg C, which is well above the ignition point of most smokeless fuels.

The stand of the Electrical Development Association (E D A) exemplified its slogan 'Plug In To Electric Living' by its comprehensive display of British domestic electric appliances. In particular, the current trend towards built-in equipment, especially 'split' cookers with separate hob and oven units, was emphasised.

*Typical of the luxury range of British cookers is this Creda 'Constellation' with two large ovens, a rotary spit and other advanced features*



*The trend towards 'rotisserie' or rotary spit cooking is steadily increasing. The spit is either placed at eye level—a notable example of this is the Jackson cooker shown here—or incorporated in the oven, as in the Creda Rosta spit and other makes*

A very strong feature of the display was electrical house warming, and no fewer than eight different methods were demonstrated, underlining the fact that electricity is the only medium that can offer such a wide choice.

Prior to the opening of the Ideal Home Exhibition, The BEAMA Domestic Appliances Division staged a special preview of modern electric cookers at which the following well-known makes were represented and the new models shown for the first time: Creda (Simplex Electric Co Ltd), English Electric (The English Electric Co Ltd), G E C (The General Electric Co Ltd) of England, Jackson (Electrical Division of Radiation Ltd), Tricity (Tricity Cookers Ltd).

The following BEAMA member-firms had at least one stand in the exhibition and many of them had two or three separate stands on which demonstrations of their various domestic electrical appliances were staged.

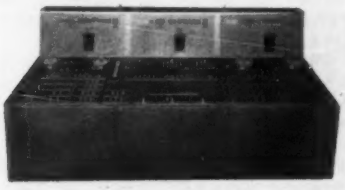
Ada (Halifax) Ltd
A E I-Hotpoint Ltd
Bakelite Ltd
Belling & Co Ltd
Berrys Electric Magicoal Ltd
Bulpitt & Sons Ltd
Burco Ltd
Dimplex Ltd
Dishlex (G B) Ltd
Easiclene Porcelain Enamel (1938) Ltd
(Rubery Owen & Co Ltd)
Electrolux Ltd
The English Electric Co Ltd
The General Electric Co Ltd
Goblin (B V C) Ltd
The Gramophone Co Ltd
('His Master's Voice')
Hoover Ltd
Kenwood Manufacturing (Woking) Ltd
Monogram Electric Ltd
Parkinson Cowan Appliances Ltd
Electrical Division of Radiation Ltd
Shell Mex and B P-Ltd
Simplex Electric Co Ltd
Thorn Electrical Industries Ltd
Tricity Cookers Ltd

# New equipment and processes

**Proportioning Control Equipment**

A new proportioning control equipment known as EGO (electronic grading operator) is announced by Dewhurst & Partner Ltd., who believe it to be the first fully-automatic multi-selection grader in its field. The equipment is designed for the control of rapid and accurate mixing of many types of materials such as aggregates, foods and so on.

EGO operates on basic units of volume of the final mix and any agglomeration of up to ten or more constituents may be obtained with a very high degree of accuracy. The pre-requisites for the operation of EGO are the storage of the mix components in fixed containers such as bins or hoppers, each with electrically controlled gravity discharge, and a conveyor system linking all the containers. By the operation of a single pushbutton, the pre-determined mix is obtained on the conveyor and can be directed to the required discharge point. EGO consists of a number of electronic units which may be housed as an entity or incorporated in an overall console or panel controlling ancillary features as well as proportioning control.



*The control console of the proportioning control equipment incorporating three E G O units*

These units include the Unit Generator which generates electrical pulses at unit delivery intervals. These pulses are transferred to a time scale known as the Unit Distributor, which records and displays on the control panel the number of pulses generated from the beginning of the discharge cycle. Each container discharge device is contactor-operated via a sensitive relay unit called a Relay Operator Unit. Each such unit can be plugged into the timing cycle at any desired point according to mix requirements via a Programme Selector Unit. This forms the heart of the equipment.

Any required programme (mixture) can be set up on a Programme Tablet which consists of a paxolin board measuring 7 by 4 by $\frac{3}{8}$ in (178 by 102 by 9·5 mm), with terminal plugs inserted at suitable spacings covering the discharge control of all the containers and delivery instructions. Positioning of the terminal plugs determines the programme. When this tablet is inserted into the Programme Selector Unit, the appropriate contacts are made and the desired programme is ready to be initiated.

EGO is not limited to the performance of a single mixing cycle at one time. By appropriate plug positioning on the Programme Tablet up to 18 consecutive mixes suitably spaced may be obtained at a single operation. This entails duplex working, *i e* mixing two batches simultaneously. Each is separately recorded. (*Dewhurst & Partner Ltd*, Inverness Works, Hounslow, Middlesex.)

**Single-Phase Thermal Ampere Demand Meter**

Intended primarily for overseas markets, Ferranti Ltd have introduced the type FMmMDA thermal ampere demand meter, which is a combination of a thermal ampere demand indicator and the Ferranti FM kWh meter in a larger case.

The design of this demand indicator, which has been incorporated in a single-phase meter, embodies many novel features such as the use of light alloy gears to reduce the weight of the unit, and viscous damping on the demand indicator pointer. Other features are a scale length of 5 in (12·7 cm), ease of calibration, low consumption, and high overload capacity.

The indicator comprises two bi-metallic strips, one of which is enclosed in a heated chamber while the other remains at ambient temperature. The heating element itself consists of a tubular former moulded in two halves from a heat-resistant plastic. In each half, strips of a copper-manganese-aluminium alloy are embedded, through which the main current is passed. Series or parallel connection can be made depending upon the current rating.

One end of the heated strip, which is about 4 in (10·2 cm) long, is firmly anchored to an insulated block and the free end is connected by an insulated link to the strip at ambient temperature. The other end of this strip is pivoted and carries a toothed sector which engages with a gear wheel mounted on a spindle which in turn drives the pointer. The retention of the maximum demand indicating pointer is provided by viscous friction between two steel plates with a silicon grease between them. This device ensures stability under conditions of vibration or shock and has the additional advantage that the mechanical burden on the meter is extremely small.

When the strip enclosed in the chamber is heated, it is deflected and operates the driving pointer. This in turn pushes the indicator pointer around the scale, where it remains at the position corresponding to the highest deflection of the driving pointer and so indicates the highest current. The second strip acts as an ambient temperature compensator, thereby making the meter independent of the surrounding temperature.

Unlike the Merz type of indicator, which has a linear scale, the thermal indicator has an approximately square law scale on which the divisions representing units of current become larger as the current increases. The time lag is 16 minutes for 90 per cent indication.

The case is of generous proportions and this results in minimum thermal interference between the indicator and the kWh meter which is also incorporated. Overall dimensions of the combined kWh and thermal ampere demand meter are: height 9·14 in (232·2 mm); width 5·75 in (146 mm); depth 5·257 in (133·5 mm). Weight is 6 lb 1 oz (2·75 kg).

Other main specification details are:

Current ratings:

(Nominal) 5 to 60 A with 50 per cent overload capacity.

Consumption:

Thermal element 7 W 7 VA } at full scale current

total 10 W 10·2 VA (maximum) } at full scale current

Overscale:

Up to 50 per cent.

(*Ferranti Ltd*, Hollinwood, Lancs.)

*The new Ferranti type FMmMDA thermal ampere demand meter*

**Grill Toaster**

A new grill toaster introduced by The General Electric Co Ltd can grill up to 18 chops in 7 to 10 minutes. Heat is controlled by two 3-position rotary switches; the elements are arranged in two banks and each bank consists of two 1·5 kW sheathed wire elements. The maximum working temperature, when both switches are in the 'high' position, is reached in approximately eight minutes.

The front and top of the grill are constructed of cast iron and the bodywork is of heavy gauge sheet steel. A stand, available as an optional extra, has a tubular steel framework and a sheet steel shelf.

Runners in the sides of the grilling chamber enable the shelf, which is 28 by 14 inches (711 by 356 mm), to be used in three different positions. The switches, neon indicators and fuses are located in an easily accessible position on the right of the grill chamber. (*The General Electric Co Ltd of England*, Magnet House, Kingsway London, W C 2.)

**Commercial Fluorescent Fittings by Benjamin**

The well-known lighting firm of Benjamin Electric have now introduced their first range of commercial fluorescent fittings as part of their general policy to broaden the field of application of their lighting fittings.

The whole of the new 'Litemaster' range is built round two basic units which are easy to install and maintain; variations to suit individual taste are made possible by introducing colour and shape to the end feature.

The two basic models types A and B, differ in size and shape; both are available for ceiling or pendant mounting, and the range includes fittings for single or twin 4 ft (122 cm) 40 W or 5 ft (152 cm) 80 W fluorescent tubes.

Type A has stepped end-plates to allow light to flow from the ends of the diffusers described below, so reducing end shadow to a minimum, or it can have enclosing end covers to meet decorative needs. Type B is available with enclosing end covers only. These end plates and covers are made in metal and in four colours: white, red, yellow and gold. There is a choice of 16 end-plate variations on type A, and 8 on type B.

The diffusers are of ribbed acrylic plastic in distinctive styles; they are designed to slip instantly into position on the channel and are just as easily disengaged.

These new fittings are based on the Benjamin 'Taskmaster' one-piece channel and incorporate the same control gear, fixing, lampholders and other details. Existing 'Taskmaster' fittings can easily be adapted to the 'Litemaster' type by a special kit comprising the diffuser and the necessary fittings. (*Benjamin Electric Ltd*, Tottenham, London, N 17.)

**Water Heater and Refrigerator by G E C**

A 2 gal (9·1 l) capacity water heater known as the 'Sto-a-way' that fits horizontally beneath basins and sinks has recently been designed by the General Electric Co Ltd. The tank is fully lagged with resin-bonded glass fibre and aluminium foil, while the heater's sheathed wire element of either 2 or 3 kW loading is controlled by a rod thermostat adjustable between 100 deg F (37·8 deg C) to 180 deg F (82·2 deg C).

The heater can be connected in a number of ways to a water supply. One version is from a ball-valve tank to feed two or three taps, in which case a vent pipe must be run back to the tank. The second version is from a mains or ball-valve tank working as a single point heater feeding one outlet only.

In addition a single point self-venting tap which completely eliminates the need for cistern tanks or vent pipes can be supplied for use with the unit. This tap has been designed to feed into standard sink and basin holes without the need for any cutting away or special fabrication.

A new 2·6 cubic feet (74 l) absorption type refrigerator has also been recently introduced. It has a shelf area of 5·6 ft$^2$ (0·5 m$^2$) and external dimensions of 32¾ in (86·5 cm) high by 21¼ in (53 cm) wide by 24½ in (61 cm) deep. The cabinet is made of steel which is finished in white or honeysuckle and has a one-piece powder-blue polystyrene interior.

Interior cabinet furnishings include three ice trays; one defrosting tray and three plated rust-proofed steel shelves. The top shelf can be turned around so that the gap normally filled by the defrosting tray can be used for the storage of tall bottles. A fully-enclosed ice-making compartment has a capacity of 168 cu in (275cm$^3$) for the storage of frozen foods. The door has a 'push-pull' toggle latch, and a handle finished in anodised aluminium with chromium-plated zinc alloy end caps that extends the full width of the door top. (*The General Electric Co Ltd of England*, Magnet House, Kingsway, London, WC2.)

**Proximity Switches Now Available for General Use**

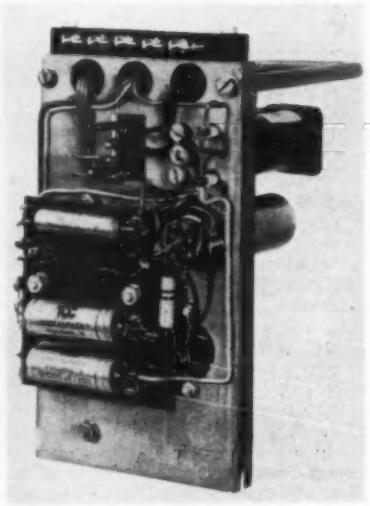
A proximity switch manufactured by the Donovan Electrical Co Ltd has been widely applied over the past five years mainly on high production machine tools, and is now being made available for general use throughout industry.

It is designed to take the place of normal limit switches in particularly arduous situations, or where it is not convenient to make physical contact with a mechanically operated limit switch. The detector head is completely sealed from oil, suds, etc, and contains no moving parts. Since there is no iron core or permanent magnet in the head, ferrous dust or swarf are not attracted.

A substantially flat metal surface of sufficient area, say 1 or 2 sq in (6·5 or 13 cm$^2$), coming within approximately 0·25 in (6·35 mm) of the flat face of the head causes a relay to operate in the control unit. The repetitive accuracy of operation depends to some extent on the method of application, but it is normally of the order of 0·020 in (0·5mm). Provided that it presents a sufficient flat surface to the head, any type or thickness of metal is detected, but swarf or metal dust normally have no effect since the particles are too small to be detected. The normal head is 1½ in (38 mm) in diameter and this is coupled to the control unit by 6 ft (183 cm) of co-axial cable. The control unit is contained in a sheet steel box measuring 7 by 6 by 4½ in (178 by 152 by 114 mm). When the rubber-sealed lid is removed, the plug-in control unit can be withdrawn from its box without disconnecting any cables.

Wide variations of supply voltage from the nominal value of 230 or 400 V are permissible. The normal power consumption of the control unit is 6 W.

Special heads for tool breakage detection, and special control units for use with static switching systems, can be supplied. The proximity switch operates on an inductive coupling principle rather than by capacitance, so that it is not affected by stray pick-up. In fact some of these units have been used in the vicinity of high power RF heating equipment with no adverse pick-up effect. (*The Donovan Electrical Co Ltd*, Granville Street, Birmingham 1.)



*The circuitry of the Donovan proximity switch*

**Increased Efficiency of Osram Fluorescent Tubes**

Using two new and unique manufacturing processes, the Osram Lamp Division of the G E C has increased the efficiency of its 8 ft (244 cm) 125 W warm white and white fluorescent tubes, which now have a total light output of 9 000 lumens for the first 100 hours and an average of 8 250 lumens throughout subsequent life. Claimed to have the highest light output of any European-manufactured tube, they will be available from July 1.

These new developments in fluorescent tube manufacture have been made possible by a fluorescent powder classification system which makes it possible to 'classify' the powder into particle sizes, selecting only those particles with the greatest efficiency; and a new water-soluble binder process which places these selected particles on the tube in such a way as to obtain maximum conversion of ultra-violet energy into visible light.

Both tubes are fitted with BC Bi-pin or RDC caps and can be used in any installation using 8 ft (244 cm) 125 W tubes. As they operate on a standard circuit and in single, twin or multi-type fittings, it is not necessary to modify either fittings or circuit.

As well as giving more light in existing installations at no extra cost in current consumption, the new tubes will make for economies in new installations because of the smaller number of fittings needed and the consequent reductions in maintenance and operating costs.

The white tube should prove most useful where high efficiency is important. Its colour appearance lies between that of warm white and daylight and it is particularly suitable for industrial applications and some shop or office installations.

The warm white tube has warmer colour-rendering properties than the white tube and is especially suitable for commercial premises, offices, factories and street lighting. (*The General Electric Co Ltd*, Osram Lamp Division, Magnet House, Kingsway, London, WC2.)

**Rechargeable Torch Battery**

A small cartridge-type rechargeable battery for electric hand torches and similar battery-powered instruments is now being marketed under the name of the Chilton Permabeam.

It is a single compact unit about 4·75 inches (12 cm) long and 1·25 inches (3·1 cm) in diameter—the same size as two standard 1·5 V torch dry cells. It consists of a blue-coloured durable plastic case containing a series of rechargeable nickel-cadmium button-type cells and provided with normal battery contacts and a 2-pin plug for the charging connection.

It can be recharged over and over again by plugging it into an a c mains socket providing 110 to 240 V and leaving it overnight or during any off-duty period.

Particular advantages claimed by the makers are that it will not deteriorate or corrode; that it is completely shock-proof; that it will store indefinitely; that the cost of recharging is negligible, and servicing is simple.

Permabeam rechargeable batteries are available in four voltage ratings, all contained in the same sized case. The standard model is rated at 2·5 V; the other models are rated at 3·5, 5 and 6 V, respectively. (*Chilton Electric Products Ltd*, Hungerford, Berkshire.)

**Tunnel Diodes**

The development of tunnel diodes—believed to be the first of their kind in Europe—is announced by Standard Telephones and Cables Ltd.

This new device exhibits a very pronounced negative resistance characteristic and its makers believe it is likely to cause a revolution in circuit designs. Because of the likely far-reaching consequences of the introduction of this new circuit element, STC are now offering devices which are at an advanced stage of their development, so that circuit designers can familiarise themselves with new properties and obtain early experience with the circuit performances which can be achieved with this component.

Sample devices are immediately available and are the forerunners of a range claimed to have a very sophisticated performance extending into the vhf region. Full details can be obtained from *Standard Telephones and Cables Limited, Transistor Division*, Footscray, Kent.

**Better Lamp Performance from New-style Filament**

To solve the long-standing problem of uniform performance whether lamps are burned in the cap-up or cap-down position, Crompton Parkinson have adopted a new style of filament design for their 100 W general lighting service lamps.

By mounting the filament in a zig-zag form instead of the conventional ring and by fully closing the filament supports, the makers claim that the advantages attained over ordinary filaments are a useful lamp life when the lamp is burned cap-up, cap-down or horizontally; a more even heat distribution in the bulb, and a better light diffusion in the case of a pearl lamp.

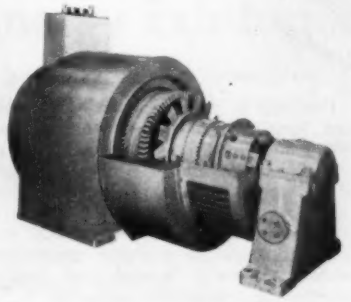
With this construction in combination with closed supports, Crompton 'Life-Light' lamps achieve a full and satisfactory life in accordance with the British Standard specification whether operated cap-up or cap-down or horizontally.

This development is at present confined to 100 W 'Life-Light' lamps and is exclusive to Crompton in the standard general lighting service range. (*Crompton Parkinson Ltd*, Crompton House, Aldwych, London, W C 2.)

**Versatile Industrial Vacuum Cleaner**

The TU4 cleaner made by the British Vacuum Cleaner & Engineering Co Ltd is claimed to be a versatile machine capable of performing tasks formerly handled only by much larger and more expensive equipment, and to be very easily handled for its volume and power. The TU4 is a development of the company's earlier T4 model and has a volume one-third greater and a more powerful motor which gives it a 50 per cent increase in suction.

This, and other BVC models, are available with 'X' equipment, which incorporates a special cyclone top which enables the machines to collect rough substances—such as metal swarf and filings—which might pierce the filter bag and damage the exhauster unit, and to deal with flour, french chalk and similar clogging powders. A special ball valve available for the same equipment equips it for wet pick-up or the collection of liquids, and a 20 inch (51 cm) floor tool can be fitted for large open area cleaning. With a 'Y' piece fitted to the inlet part, two operators can work simultaneously for collecting light dust, overhead cleaning of walls and girders, and similar purposes. (*British Vacuum Cleaner & Engineering Co Ltd*, Leatherhead, Surrey.)



*This is a part-sectioned view of the A E I Brushless Marine Alternator*

**Brushless Marine Alternators**

The Heavy Plant Division of Associated Electrical Industries Ltd announce an extension of the range of their brushless marine alternators, which are now available up to 1 750 kW at four-pole and six-pole speeds. These machines will be specially built to the requirements of the individual customer and will be provided with self-ventilated enclosures or closed-air circuits suitable for sea water-cooled air coolers.

As the machine has no slip-rings and commutators, there is no danger of carbon dust entering the windings. It is a self-compounding machine, employing shaft-mounted silicon rectifiers and an a c excitation system, and the final control of output voltage is achieved by a small trimming regulator. The voltage regulator and associated parts are therefore easily housed within the normal type of switchboard. (*Associated Electrical Industries, Ltd, Heavy Plant Division*, Rugby, England.)

**Light- and Medium-Duty Spot-Welding Machines**

Electro Mechan-Heat Ltd have introduced a new range of small spot-welding machines designed particularly for the requirements of light industry.

The new light-duty machines are at present available in two sizes rated at 8 and 16 kVA respectively. Two larger air-operated models with ratings of 30 and 40 kVA will be on the market shortly.

These machines have been designed specifically for the smaller workshop and are priced some £70 below equivalent machines previously obtainable. They will therefore make spot-welded assembly an economic proposition for many applications in which it was formerly considered too expensive. Among these are the manufacture of sheet-metal cabinets for the electronics, automation, refrigeration and office equipment industries, using metal up to 18 s w g, as well as ornamental wire-work, fire guards etc, using metal up to 10 s w g.

The small 8 kVA spot-welder is manufactured in two models designated as types PM 11 and PM 11 V. Type PM 11 is available with either 12 inch (305 mm) or 18 inch (457 mm) arms, of which the lower arm is adjustable in height to give a variable distance between arms of from 4·5 inches (115 mm) to 6·4 inches (165 mm). Type PM 11 V has a greater range of adjustment, since its lower arm slides on a vertical pillar and is also reversible; this enables the distance between arms to be varied from 4·5 inches (115 mm) to 17·9 inches (455 mm).

The 16 kVA machine is again produced in two models: PM 21 and PM 21 V. Both models can be supplied with 12 inch (305 mm), 18 inch (457 mm), or 24 inch (610 mm) arms. Model PM 21 has a range of adjustment between arms of from 5·7 inches (145 mm) to 7·6 inches (195 mm); in model PM 21 V, a reversible lower arm allows the distance between arms to be varied between 5·7 inches (145 mm) and 20·6 inches (525 mm).

All the machines are fitted with a pedal-operated 'trip' type switch, the weld pressure being determined by adjustable compression springs attached to the pedal mechanism. The weld-time depends upon the speed with which the pedal is depressed, but it will be found, say the makers, that surprising consistency of working can be achieved by an unskilled operator after relatively little practice.

As an alternative, any of the machines can be fitted with an electronic timer which comes into operation as soon as the compression springs have established weld pressure. It is of the non-synchronous type employing cold cathode type valves. No warm-up period is necessary, and the timer has a normal life of more than 50

million operations before any service need be carried out. Weld-times of from 3 to 70 cycles can be selected with an accuracy of ±5 per cent. The subassembly containing the timer is so designed that it can be fitted as an extra to the standard machine after it is in service.

The machines are finished in light or dark grey enamel and are supplied crated, with full installation and operating instructions. They are designed for either a 230 or 440 V single-phase supply, and with their low power consumption, are ready for immediate connection to any small industrial power circuit. (*Electro Mechan-Heat Ltd*, Manor Works, Ettingshall, Wolverhampton, Staffs.)

**Buried Oil-filled Distribution Transformers**

Ferranti Ltd, who are one of the pioneers in the United Kingdom of buried dry Class C insulated transformers† as a convenient means of reinforcing existing electricity supply networks, have now introduced buried oil-filled units using conventional Class A insulating materials.

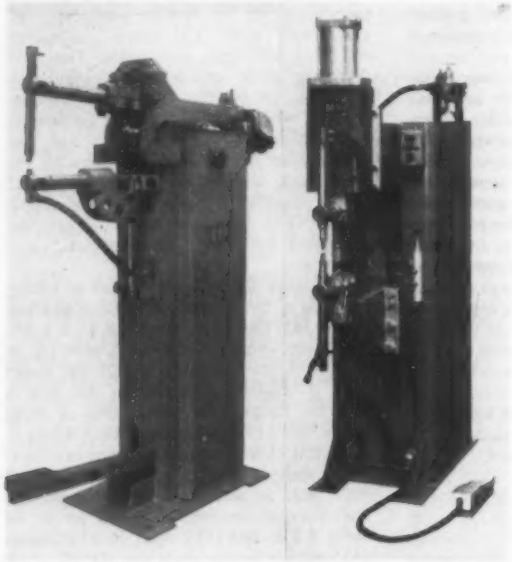
A 750 kVA, 6·6 kV /433 V, 3-phase 50 c /s unit of this type was recently commissioned in the North Western Electricity Board's area and has been operating satisfactorily under distribution system load conditions. Before installation it was tested to the requirements of BS171 : 1959 under simulated operating conditions in the company's works.

The buried oil-filled Class 'A' insulated transformer is less expensive than the buried dry Class 'C' insulated transformer and offers similar advantages to supply authority engineers. It can be buried at a load centre without difficulty, in contrast to the more conventional methods of reinforcing low voltage networks by replacing existing transformers with units of larger rating, or attempting to acquire new sub-station sites which may not be readily available near the load centre.

The transformer core and windings are contained in a strongly protected tank which can be buried directly in the ground with only a comparatively small ventilating pillar showing above the surface. The above-ground cooling arrangement, comprising radiator and protective housing, is designed on the lines of an over-ground distribution pillar. As it is offset to one side of the tank, the core and coils can be removed without difficulty if required. The pillar is fully weatherproof; sampling and filtering of oil can be carried out from above ground, and tamper-proof access to the oil level indicator, silica gel dehydrating breather and thermometer pocket is provided. (*Ferranti Ltd*, Hollinwood, Lancs.)

**A New Radiant Heater by A E I**

An entirely new product, the Slimline radiant heater, has been introduced recently by the Heating and Welding Department of Associated Electrical Industries Ltd.



*Two models from the new range of spot-welding machines by Electro Mechan-Heat Limited. On the left is one of the 8kVA light-duty machines (type PM 11 V); on the right one of the medium-duty spot welders (type M 50 mark III) which has a nominal rating of 50 kVA at 50 per cent duty cycle*

Designed in a contemporary style, the new Slimline radiant heater has slender lines which give it a pleasing and unobtrusive appearance. Available in ratings of 1, 2 or 3 kW, it is suitable for a wide range of indoor applications in industry and commerce.

The body is of extruded aluminium section, naturally finished and highly resistant to atmospheric corrosion. It is 3½ in (89 mm) wide and 1½ in (38 mm) deep, the length varying according to the rating—3 ft 3 in (99 cm) at 1 kW, 5 ft 10 in (178 cm) at 2 kW and 8 ft 6 in (259 cm) at 3 kW.

The heating element is the well-known A E I Pyrobar Inconel Sheathed Element. The aluminium reflector has an anodised mirror finish and is parabolic in shape, giving a beam angle of approximately 50°. The only maintenance required is an occasional wipe with a damp cloth and should the reflector be accidentally damaged in any way it can easily and quickly be replaced.

In designing the heater, special attention has been paid to mounting arrangements in order to make the installation as simple as possible and at the same time to offer a wide choice of mountings. Thus the heater, supplied complete with special adjustable brackets, can be mounted direct to wall or ceiling at any desired angle; can be suspended from rod, wire or chain with either vertical or angled beam, or can be suspended from conduit or lighting trunking. A feature of special interest is that the heaters can be mounted in pairs, angled on the brackets supplied, to give a beam of either twice the width or twice the intensity of a single heater.

The element guard is an optional extra, and to simplify stocking it has been designed in unit form to suit all three sizes of heater. (*Associated Electrical Industries Ltd*, Heating and Welding Department, Transformer Division, Trafford Park, Manchester 17.)

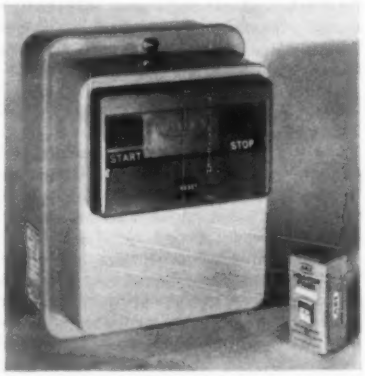
**Starter with Single-phasing Protection**

An entirely new 5 h p starter for 3-phase and single-phase motors has been introduced by A E I. Known as the DOC 80, it is stated to be the lowest-priced unit on the market giving single-phase protection on 3-phase supplies.

It incorporates an ambient temperature compensator to allow for differences in local temperature between the starter and the motor, and a set of overload heaters is supplied separately in a small pack. These overload heaters can be fitted very quickly to make the starter ready for service.

There are 15 different heater ratings which, with the calibration control, enable the relay to give precise protection to the motor. As supplied, the starters are fitted with any one of five coils covering standard voltages. These, together with the range of 15 overload heaters, will give 75 possible variations of the starter. Thus only a minimum stock of starters is required to cover a wide range of ratings.

The starter can be easily mounted by three-point fixing from inside the case without the removal of any component. Wiring is simple and leads can be taken out from the top, bottom or side. (*Associated Electrical Industries Ltd, Motor and Control Gear Division*, Industrial Control Gear Sales, Marsden Mill, Nelson, Lancs.)




*The A E I starter switch with single phasing protection, and on the right the pack containing a set of overload heaters*

† THE BEAMA JOURNAL **66**, No 4, p 127

# The Engineering, Marine, Welding, and Nuclear Energy Exhibition

THIS well-known international exhibition, held every two years at Olympia, London, opened this year at the time this issue of THE BEAMA JOURNAL was going to press, and a survey of the equipment and developments revealed at the exhibition will therefore appear in our next issue.

The exhibitors in the engineering, marine and nuclear sections included 34 BEAMA member-firms. The Welding Exhibition, which is organised by the Welding Section of The BEAMA, forms a self-contained exhibition within the main exhibition, and 15 out of the 43 exhibitors were BEAMA member-firms.

The following notes indicate briefly some of the more novel items seen at the Exhibition.

**Boilers**

Computer systems for the operational control of large boilers was the subject of a display by Babcock and Wilcox Ltd, who have ordered a Ferranti 'Argus' computer to control the start-up and shut-down of a 200 MW boiler for the new West Thurrock power station in Essex. The 'Argus' employs solid state electronic components throughout and is able to calculate 50 000 additions or 10 000 multiplications per second, using binary arithmetic.

**Locomotives**

A complete British Railways Type 1 diesel-electric locomotive was brought by road from Darlington to London—a distance of 250 miles (402 km)—to be the English Electric Company's main exhibit. The locomotive, which is 46 ft 9 in (14·24 m) long and weighs 72 tons (73 155 kg), is powered by an 8-cylinder SVT diesel engine developing 1 000 h p.

**Alternators**

A 250 kW diesel-alternator set with a 5-cylinder, 360 b h p, 428 rev/min dual fuel engine, was shown by W. H. Allen, Sons & Co Ltd, while Associated Electrical Industries (Manchester) Ltd showed a 700 kW back-pressure marine auxiliary turbine generator to operate at steam conditions of 550 lb/in$^2$ (38·67 kg/cm$^2$) and 890 deg F (476·7 deg C) to exhaust at 31 lb/in$^2$ (2·179 kg/cm$^2$) to a low-pressure steam power system.

**New Pumps**

Five new pumps by Worthington Simpson Ltd, including a cargo oil pump of the horizontal split-casing single-stage centrifugal type, were on show in the fluid handling section. The cargo pump can be arranged for steam turbine or electric motor drive through inter-

shafting fitted with combined bulkhead bearings and seals. It will handle 1 350 tons (1 371 68 kg) an hour against a pressure of 50 lb/in$^2$ (3·515 kg/cm$^2$) when run at 1 800 rev/min.

**Welding**

The new 'Vertomat' machine, for the vertical welding of plates from $\frac{1}{2}$ in (12·7 mm) upwards by the $CO_2$ shrouded-arc process was shown for the first time by Rockweld Ltd. The machine is fitted with two water-cooled shoes to box the weld metal between the plates. A speed of 21 ft (6·4 m) an hour on $\frac{5}{8}$ in plate (15·87 mm) has been achieved.

The British Federal Welder and Machine Co Ltd showed a new automatic drum forming and welding machine, able to produce 400 45-gal (204 l) drums an hour. The company also showed an automatic wire-mesh welder for road reinforcement mats 15 ft (4·57 m) in width.

A welding unit for the semi-automatic hand welding of mild steel fabrications was introduced by the Lincoln Electric Co Ltd, who were also displaying a fully automatic $CO_2$ welding head with a high-speed wire feed gear box and a water-cooled nozzle with detachable tip.

Among the many welding accessories was the 'Thermees' electrode by the English Electric Co Ltd for applying a rapid and concentrated heat to otherwise inaccessible parts of workpieces before welding or bending operations.

A new high-precision electronic timer for spot and projection welders was exhibited by Sciaky Electric Welding Machines Ltd, while Crompton Parkinson (Stud Welding) Ltd have perfected shrouded-arc welding equipment with a valve attachment which allows argon gas to be directed through nozzles on to the weld position for the duration of the weld.

The latest type of 'Polytrode', shown by the Arc Manufacturing Co Ltd, for welding non-ferrous metals with coated electrodes, has a spark gap ioniser which facilitates arc welding by superimposing a high-frequency current on the normal low-voltage welding current. It can be used together with standard a c or d c welding machines.

Standard Telephones and Cables showed for the first time the 'Stanelco' G 300 and G 400 electro-gas process heating equipments for soldering, brazing and hardening applications requiring precise control.

**Metallurgical Examination**

A resonance bending fatigue machine for investigating the fatigue strengths of tubes and welded joints was demonstrated in action by Stewarts and Lloyds Ltd. The machine is used for testing the tubes of nuclear boilers, which are subject to vibrations set up by the gas flowing over them.

**Furnace in Action**

A working model of a Birlec sealed quench furnace was exhibited by A E I-Birlec Ltd, showing its full operating cycle and latest improvements, including new horizontal radiant tubes.

**Nuclear Engineering**

In the field of nuclear engineering Babcock and Wilcox Ltd showed models of nuclear steam raising plant for merchant ships and for the new 580 MW nuclear power station to be built by the English Electric-Babcock and Wilcox-Taylor Woodrow atomic power group at Sizewell in Suffolk.

Among the nuclear exhibits were many reactor components, of which one—by W. H. Allen, Sons & Co Ltd—was the 1 150 h p epicyclic speed-reducing planetary gearing for pumps operating between 980 and 180 rev/min in a nuclear power station.

**Marine Fittings**

The General Electric Co Ltd of England, who supplied for the s s *Oriana* 'Mutac' switchgear and the largest hot-cathode direct lighting installation afloat, displayed steam-proof and drip-proof fluorescent lighting for machinery spaces, and a new double-oven ship's galley.

BEAMA member-firms taking part in the Exhibition were as follows. Those marked * also had separate stands in the Welding Exhibition.

A E I-Birlec Ltd
Aiton & Co Ltd
W. H. Allen, Sons & Co Ltd
* Associated Electrical Industries (Manchester) Ltd
Associated Electrical Industries (Rugby) Ltd
Arc Manufacturing Co Ltd
Babcock & Wilcox Ltd
Birmingham Battery and Metal Co Ltd
British Federal Welder & Machine Co Ltd
Brush Electrical Engineering Co Ltd
Castrol Industrial Ltd
Crompton Parkinson (Stud Welding) Ltd
Dowty Electrics Ltd
Drysdale & Co Ltd
* English Electric Co Ltd
Fuller Electric Ltd
Garringtons Ltd
General Electric Co Ltd of England
Gwynnes Pumps Ltd
Heatrae Ltd
Holden & Hunt Ltd
James Howden & Co Ltd
Invicta Electrodes Ltd
Laurence, Scott & Electromotors Ltd
Lincoln Electric Co Ltd
Joseph Lucas Ltd
Mawdsley's Ltd
Mirrlees Watson Co Ltd
G. D. Peters & Co Ltd
Philips Electrical Ltd
Richardsons, Westgarth & Co Ltd
Rockweld Ltd
Sciaky Electric Welding Machines Ltd
Shell Mex & BP Ltd
* Siemens-Schuckert (G B) Ltd
* Smiths Industrial Division
Solus-Schall Ltd
Standard Telephones & Cables Ltd
Stewarts & Lloyds Ltd
Turners Asbestos Cement Co Ltd
Watson & Sons (Electro Medical) Ltd
G. & J. Weir Ltd
Westinghouse Brake & Signal Co Ltd
Worthington Simpson Ltd
Yorkshire Imperial Metals Ltd

# Pulverised Fuel Ash

## NEW USES FOR A WASTE PRODUCT

A BY-PRODUCT of generating electricity in conventional stations is pulverised fuel ash, the disposal of which has presented an ever-increasing problem as more and more stations have come into operation. For many years it has been the practice to get rid of this supposedly waste product in dumps and pits, or to take it out to sea. Now, however, pulverised fuel ash is rapidly becoming a valuable and economical contribution in building and civil engineering works.

The output of this material from power stations in the U K was about 750 000 tons in 1947, which had risen to about 4 million tons in 1960.

In coal-fired power stations the pulverised coal, suspended in air, is burned in the combustion chambers of the furnaces, and the ash is fused into small separate spheres, some of which are hollow. As it emerges from the combustion chambers it is collected by electrostatic precipitators.

The pulverised fuel ash at this stage is similar to the volcanic ash or *pozzalanas* used by the ancient Romans in combination with calcined limestone as a cementing material when they built their great and historic structures such as the Colosseum and the Pantheon in Rome.

This combination still had a widespread use even until the discovery of Portland cement less than 150 years ago, but only in recent years have the possibilities suggested themselves of using pulverised fuel ash as a modern equivalent, with the added advantage that, unlike *pozzalanas* found in the earth's crust, pulverised fuel ash is already finely divided and needs no crushing or pre-treatment.

Research into the economic utilisation of pulverised fuel ash has now yielded enough data to provide a basis for extensive commercial development, and the most promising lines seem to be:

(*a*) Mixed with clay to produce bricks.
(*b*) To replace part of the cement, or sand, in concrete.
(*c*) To make concrete-type building blocks.
(*d*) To form, by sintering, a lightweight aggregate.

**Bricks**

Experimental work by the Building Research Station and several commercial firms has demonstrated that it is possible to make good bricks from pulverised fuel ash and clay in the proportions of 80 to 90 per cent ash and 10 to 20 per cent clay, provided the clay is of the plastic kind.

On a laboratory or pilot scale, bricks of good average quality have been made from 85 per cent of pulverised fuel ash from Hams Hall power station, Birmingham, and 15 per cent Wilnecote clay, both slurry-mixed and dry-mixed and fired at temperatures ranging from 900 to 1 090 deg C.

Trials with Hams Hall ash mixed with clay in the proportion 60 : 40 have been carried out at two of the National Coal Board's brickworks in the Midlands Division. When submitted to the usual tests, the bricks containing the pulverised fuel ash from one works did not differ significantly from those made entirely from clay. At the other works, those containing the ash were slightly more porous and slightly lower in strength; but both sets of bricks containing ash were of excellent quality.

In Surrey and Sussex several brickworks are successfully using pulverised fuel ash in varying proportions.

Since it is unusual to find an existing brickworks near enough to a power station to dispense with the need to move the ash either by road or rail transport, the means and cost of such transport presents a problem. The ideal vehicle for the purpose would probably be something on the lines of the spherical containers now widely used for the pneumatic delivery of cement in bulk, but this problem need not present insuperable difficulties once there is a firm long-term demand for pulverised fuel ash in quantity.

Another way round the transport problem would be the erection of new brickworks adjacent to a power station and preferably located near a big market for bricks.

**Concrete**

Experiments at the Central Electricity Generating Board's Research Laboratories at Leatherhead have confirmed American (and Russian and German) experience that concretes in which up to 20 per cent of the cement has been replaced by pulverised fuel ash have a rather lower initial strength than ordinary concretes. But with the lapse of time the strength approaches that of ordinary concrete, and at three months the two are equal. This is to be expected, since the pozzolanic action of the fly-ash depends on the lime set free by the hydration of the cement, and this increases with time.

For mass work where there is no early load to bear, this slower strengthening has advantages. Compared with straight Portland cement concrete, that containing pulverised fuel ash gives off less heat, so that temperature gradients across large masses of concrete are smaller and the danger of surface cracking is thereby reduced. Users say there is less segregation of aggregate and less 'bleeding' with fly-ash concrete and that it is more resistant to attack by sulphates and the action of sea water. It is also claimed that fly-ash concrete is rather more workable.

In Great Britain fly-ash concrete is already being used by the North of Scotland Hydro-Electric Board for dams and other civil engineering work. Concrete con-

*This general view of the site works for the Bold 'B' power station shows clearly the foundations for the turbine and boiler houses. The interesting feature is that pulverised fuel ash replaced 20 per cent of the cement used in the concrete for this work*

taining p f a is used by the C E G B in civil engineering works, both large and small, throughout the country, *e g* in the dams now under construction for the Blaenau Ffestiniog and Rheidol hydro-electric projects and the nuclear power station at Trawsfynydd.

**Building Blocks**

Methods have been perfected of manufacturing from pulverised fuel ash building blocks designed to replace bricks, concrete and masonry in all forms of walling, both load-bearing and otherwise. Names known to the industry include 'Melcrete' and 'Thermalite'.

The aim is to secure speedier, cheaper and perhaps better building; higher thermal insulation; lower loads to transport, and easier and better finishing or facing. Such blocks use a very high proportion of fly-ash and will probably in time absorb a high proportion of the output of some power stations.

**Aggregates**

By a sintering process, pulverised fuel ash can be made into a lightweight aggregate approximately half the weight of gravel. The concrete made with such aggregate has not the full load-bearing qualities of that made with the usual aggregates, but a very large proportion of concrete work is not required to bear heavy loads; it is used, for example, to cover, clad and fill in steelwork. In such applications the reduction in weight for a given volume has important advantages. A lighter concrete cladding means a lighter steel structure and a saving of metal. At works, the cost of pulverised fuel ash aggregate per ton will probably be rather higher than the cost of gravel. But as less weight will be required for a given volume of concrete, the higher cost per ton at works should normally be offset by savings on transport and in the weight of aggregate required.

Indeed, since the pulverised fuel ash aggregate can frequently be made very near the building site—at power stations in cities, towns and populous areas, for example, while gravel pits are often remote—it may well prove, ton for ton, no more expensive than gravel delivered to the site where it is required. Moreover, a ton of pulverised fuel ash aggregate will go nearly twice as far.

Production began at Battersea power station in London in 1958, and here a well-known building contractor has a plant for processing the station's entire output of pulverised fuel ash. Since the national output of aggregate of all kinds approaches 40 million tons a year, this outlet for pulverised fuel ash holds out considerable promise.

While the main use for p f a aggregate would appear to be for lightweight concrete, it could also be used to make building blocks in substitution for the well-known clinker block made from power station clinker. Possibly bound with p f a cement, these aggregate blocks would be roughly of the same weight as clinker blocks but considerably stronger and generally better products. Successful experiments in making them have already been carried out.

Although the known methods of utilising pulverised fuel ash have not yet been commercially exploited on any widespread scale in this country, the material promises to be of considerable value to the building and civil engineering industries, while the quantity available is constantly growing. By no means all the possibilities have yet been explored, and there is obviously scope for the development of new techniques which might prove very profitable to the building and building materials industries.

# Book Reviews

**Compression and Transfer Moulding of Plastics.** *By J. Butler, A M I Mech E, F P I.* $8\frac{1}{2} \times 5\frac{1}{2}$ *in* (214 × 140 *mm*). *Pp* 230. *Line and half-tone illustrations.* (*Iliffe & Sons Ltd, for the Plastics Institute.*) Price 35s net.

It is obvious from the title that this is a book for the specialist, and for him it displays clearly and simply the results of what must have been many years of practical work in the field of mould design. The author says in his preface that 'since 1926 he can claim to have made as many mistakes as anyone in the industry'. He recognises that mould design can only be taught to a limited degree by any sort of textbook and is mainly advanced by making mistakes and recognising them. We can, however, hope that fewer mistakes will be made in future by the readers of Mr Butler's book.

He deals first with the different types of moulds and then the treatment of cavities, and goes on afterwards to moulding procedures with various types of powders.

The second part of the book relates to transfer moulding—a process that has largely revolutionised certain parts of the industry since it was first introduced in about 1930.

At all times Mr Butler has an engaging habit of taking the reader into his confidence. For example, when describing the evolution of a transfer mould he says 'Assume that we, the reader and the author jointly, were concerned in producing such a job in quantity at such a time; that the order was placed and quality plus efficient production was the first consideration; that we had some knowledge of transfer moulding backed by some—though at the same time necessarily limited—experience of the method'. Disarmed in this way, we can enter into the very closely detailed discussion of the design of a typical mould with the feeling that we are learning with the author and are profiting by what might have been our own mistakes.

J.H.M.S.

**The Relay Protection of High-Voltage Networks.** *By G. I. Atabekov.* $10 \times 6\frac{1}{2}$ *in* (254 × 165 *mm*). *Pp xii* + 564. *Index. Illustrated.* (*London: Pergamon Press.*) Price 84s net.

The book is a translation from the Russian and it is concerned almost entirely with transmission line protection. It is a theoretical monograph on the subject and embraces the technique of relay protection and the theory of the calculation of short-circuit currents by symmetrical components. Considerable use is made of vector loci circle diagrams and, among others, there are chapters on power directional devices, distance and carrier protection, and differential current protection of lines and busbars.

The book is freely illustrated and it is a useful record of Russian practice on relay protection in high-voltage transmission line engineering.

**Economic Control of Interconnected Systems.** *By Leon K. Kirchmayer.* $9\frac{1}{4} \times 6\frac{1}{4}$ (235 × 159 *mm*). *Pp ix* + 207. *Index. Illustrated.* (*London: Chapman & Hall.*) Price 100s net.

The author's book *Economic Operation of Power Systems** was published in 1958 and at that time the present volume was in preparation. The two will now be found to be complementary—operation on the one hand and control on the other, with economy of purpose as the overall guiding principle. They also have common ground in that both employ matrix and tensor methods of analysis and in doing so bring into high relief the outstanding value of these modern techniques in deriving solutions to really complex problems.

Dr Kirchmayer's new book is directed principally to a study of computers, controllers, and theoretical methods to obtain optimum economic operation of interconnected power systems. In reaching out to that objective he discusses analyser methods, mathematical models, matrix and tensor concepts including Gabriel Kron's diakoptics, equations of optimal performance, and computer-controlled integration for system control.

Chapter 1, on control analysis of power systems, discusses descriptively and mathematically the steady-state and dynamic performance of systems as affected by speed-governing and control characteristics, with particular reference to tie line and frequency control performance.

Chapter 2 deals with the computer control of steam-electric plants within a given area, referring thereby to an automatic dispatching system for simultaneously and automatically maintaining frequency, net interchange of power, and economic allocation of generation within the operating area. Chapter 3 is concerned with the economic operation of a combined steam and hydro-electric power system and gives a method for the short-range optimum economic scheduling of outputs of the two classes of plant, taking rigorous account of transmission losses.

Chapter 4 deals with energy accounting and related operating practices in interconnected systems, while chapter 5 describes methods of calculating analytically the transmission losses in interconnected areas. This is where we first encounter Kron's diakoptics, aided by matrix analysis, and a knowledge of the methods presented here is required for an understanding of the remaining three chapters of the book.

Chapter 6 is on the theory of economic operation of interconnected areas and it derives the equations for optimum economic operation of a pool operated as a multiple-area system. Chapter 7 incorporates the ideas of the previous chapter in discussing computer controllers which maintain economic allocation of generation within an area and also frequency and optimum net interchanges between areas. Chapter 8 describes a multi-area economic dispatch computer capable of calculating economic interchange of power between areas, weighted incremental losses at boundaries, incremental costs of wheeling losses, and power flows over individual tie lines.

The book contains selected bibliographical references and set problems, as did the author's previous work, and it is very well illustrated and indexed.

It would be very difficult to overrate the importance of this exceptional book. It is a masterly study of a subject that is already complex and that is growing ever more so because of the real expansion of power systems, increasing numbers of generating stations to meet the modern demands for electricity, and the imperative need for widespread interconnections for the constant maintenance of supplies, for economic operation, and for the routine overhaul of plant.

We forecast that only the intellectually improvident power supply engineer will neglect this book and its predecessor.

S. AUSTEN STIGANT

* THE BEAMA JOURNAL, **66**, No 3, p 118

**Electric Circuit Theory.** *By F. A. Benson and D. Harrison.* $8\frac{1}{2} \times 5\frac{3}{4}$ *in* (214 × 146 *mm*). *Pp. viii* + 371. *Illustrated. Index.* (*London: Edward Arnold Ltd.*) Price 30s net.

This new book on electric circuit theory is based on lectures given to undergraduate engineers at the University of Sheffield during the first two years of their degree course.

The text of 15 chapters, illustrated by 350 diagrams and figures, covers successively d c circuits, single-phase and polyphase a c circuits, complex quantities, subsidiary network theorems and principles, coupled circuits and transformers, circle diagrams and inversion, non-sinusoidal waves, unbalanced polyphase circuits, transients, thermionic valve circuits, communication circuits and electrical machines. There are also three appendices on Cramer's Rule, minors of a determinant, and finally the conversion of bel, decibel and neper.

The authors have provided throughout the text a total of 107 fully worked numerical examples, and at the end of each chapter there are further problems—to a total of 240—by which the reader can test his progress.

The contents deal with both light and heavy current application of electric circuit theory. The treatment is restricted to linear circuits, which is a pity, as there are many simple non-linear circuits which first- and second-year students should learn how to solve. The book is essentially a student's textbook and the text is of the detailed type so popular with modern students.

The book has an attractive format, which is conducive to easy reading. Any student who has diligently read the text and solved all the examples will be well prepared for more exacting future studies of this very important basic subject of electrical engineering.

P. F. SOPER

**The Cathode-Ray Tube and its Applications.** *By G. Parr and O. H. Davie.* $8\frac{1}{4} \times 5\frac{1}{2}$ *in* (222 × 140 *mm*). *Pp xii* + 433. *Index. Illustrated.* (*London: Chapman & Hall.*) Price 50s net.

This is a completely revised edition of an old favourite text first published in 1937; it has indeed now come of age. The book has much new material which covers the major developments well but by no means exhaustively or tediously. The original plan of being a general guide to users of cathode ray oscilloscopes has been retained successfully.

The style of writing is plain and simple; the explanations given are easy of comprehension and in every way admirable. All the 287 line diagrams and 58 photographic plates are well produced and aptly chosen.

To each chapter is appended the corresponding list of references and these are ample to give the serious research worker a lead into an extensive existing literature. In addition to these, footnotes (81 in all) including important patent numbers are given where needed.

The sixteen chapters of the book are laid out in logical sequence and the browser can readily track down particular information either by reference to the table of contents or to the detailed index.

After a brief historical survey chapter, the authors have devoted four chapters to practical constructional and design details, power supplies, amplifiers and time bases. These are followed by five chapters describing the methods, auxiliary circuits and equipment which the user may himself employ or devise for use with the oscilloscope, *e g* calibration, frequency bases, photographic recording and transducers. The next five chapters describe the applications of the cathode ray oscilloscopes in mechanical, electrical, radio, television and nuclear engineering. The sixteenth and final chapter gives a miscellaneous collection of applications including electromedical equipment, special patterns on the screen, three- and four-dimensional displays and computer applications.

Summarising, the book is invaluable in practically every research and development laboratory using the cathode-ray oscilloscope; that is, in practically every laboratory. This book is devoted to the most versatile scientific research tool ever invented; however, the authors themselves add a timely warning in their preface: 'In no other instrument is the observer so prone to see what he wants to see.'

**Rapid Statistical Calculations.** *By M. H. Quenouille.* $6\frac{1}{4} \times 4\frac{1}{4}$ *in* (159 × 180 *mm*). *Pp* xv + 81. *Illustrated.* (*London: Griffin.*) Price 10s net.

This pocket manual has been written with the objective of making available a collection of rapid statistical methods which presents the practical details in a brief, straightforward fashion. There are in all thirty-five methods, each method and an example of its use being given on a pair of facing pages. The book is concluded by some short statistical tables for use with the text, and a bibliography showing where further information can be obtained for each method.

The methods detailed come under the following general headings:—

A. Methods involving mean level or scatter of groups of observations. (18 methods.)
B. Methods comparing frequencies or proportions. (4 methods.)
C. Methods involving association. (13 methods.)

To quote but a number of the methods covered, we have estimation of mean level and spread, test of differences between groups of observations, test of goodness of fit of a distribution function, estimation of covariance, correlation and linear regression, graphical estimation of linear regression for a series of equally spaced observations and graphical test of monotonic association between two time-series.

The most popular group of statistical methods are those in which it is assumed that the observations (or their residuals) are normally distributed. In practice this may not be a satisfactory approximation, and the author has made this book invaluable by including and specifying as many as eighteen distribution-free methods. Even when the assumption of normality is valid it may be simpler to use a less-efficient method that requires fewer calculations and perhaps to take a few more observations to compensate for the loss in efficiency. Such methods have also been marked in the list of contents, as have methods that are both distribution-free and involve only counting procedures. A rough guide to the efficiency of each method is specified, the measure of efficiency being derived by determining the relative numbers of observations needed to achieve equally accurate results by the given method and by the best-possible method.

There is no doubt that this booklet contains a wealth of statistical calculations methods, and that it is well worth its small cost on the grounds of time and energy saved in looking up one or more larger volumes. I am certain that it will find wide use.

H. GOLDENBERG

## SHORTER BOOK REVIEWS

**Direct Current Machines.** *By H. B. Ranson and E. T. A. Webb.* $7\frac{1}{2} \times 5$ *in* (190 × 125 *mm*). *Pp* 320. *Illustrated. Index.* (*London: Cleaver-Hume Press Ltd*, 1960.) Price 21s net.

This is the second edition of volume 2 in the Cleaver-Hume Electrical Series, which is compiled under the general editorship of Professor H. Cotton. Owing to the untimely death of the co-author and racing driver, Humphrey Ranson, all the revisions have been undertaken by Mr Webb.

**Wireless & Electrical Trader Year Book.** $8\frac{1}{2} \times 6$ *in* (216 × 152 *mm*). *Pp* 456. (*London: Iliffe Books Ltd*, 1961.) Price 15s net.

This important reference book was first published in 1925 and is now in the 32nd edition. It is a standard guide to the radio and domestic electrical industry and should be of assistance to overseas buyers seeking sources of supply of British equipment.

**British Nuclear Power Stations.** *By Rolt Hammond.* $9 \times 5\frac{3}{4}$ *in* (228 × 146 *mm*). *Pp* 182. *Illustrated. Index.* (*London: Macdonald & Co*, 1961.) Price 25s net.

This work tells the story of the development of British nuclear power stations, with many details of Calder Hall, Hinkley Point, Berkeley, Bradwell and Hunterston power stations. Written in non-technical language, it will be of value to all readers who are interested in the use of nuclear power.

**Foundation and Soil Properties.** *By Rolt Hammond.* $9 \times 5\frac{3}{4}$ *in* (228 × 148 *mm*). *Pp vii* + 181. *Illustrated. Index.* (*London: Macdonald & Co*, 1961.) Price 30s net.

This book will be of interest to all engaged in engineering and constructional work. It covers selection of site, geographical prospecting, piling and other processes involved in preparing a site for constructional work.

**Michael Faraday: A List of His Lectures and Published Writings.** *By Alan E. Jeffreys.* $10 \times 7\frac{1}{2}$ *in* (254 × 191 *mm*). *Pp xxxviii* + 86. *Illustrated. Index.* (*London: Chapman & Hall Ltd*, 1960.) Price 42s net.

This is a bibliography which lists in chronological order Faraday's books, articles, papers, letters to the press, lectures and manuscript notes. The author has also included a list of the main biographies of this outstanding scientist.

**A Physics Anthology.** *Edited by Norman Clarke.* $8\frac{1}{4} \times 6$ *in* (222 × 152 *mm*). *Pp viii* + 324. (*London: Chapman & Hall Ltd*, 1960.) Price 35s net.

This book consists of a wide selection of articles which have appeared in the Institute of Physics Bulletin over the past few years. The articles which have been selected are signed by such well-known personalities as Sir Cyril Hinshelwood, Sir John Cockroft, Professor Allen Bullock and many others. The purpose of publishing this anthology is to make these articles available to a larger readership.

**Engineering Management.** *By Struan A. Robertson.* $8\frac{3}{4} \times 6\frac{1}{2}$ (222 × 159 *mm*). *Pp xii* + 467. *Index.* (*London: Blackie & Son Ltd*, 1960.) Price 30s net.

The first edition was published in 1948 and was the basis of a course of lectures at Battersea Polytechnic for National Certificate students. The second edition has now been adapted to the changes in industry that have occurred during the last twelve years, the principal event being the formation of the British Institute of Management.

**Heat Engineers.** *By Eric de Ville.* $7 \times 4\frac{1}{2}$ *in* (178 × 114 *mm*). *Pp* 220. *Illustrated.* (*London: English University Press*, 1960.) Price 7s 6d net.

This is one of the series of 'Teach Yourself' books. It is an elementary and easy-to-read text book and covers the work needed for National Certificate Courses. There is a selection of set and worked examples with answers at the end of each chapter.

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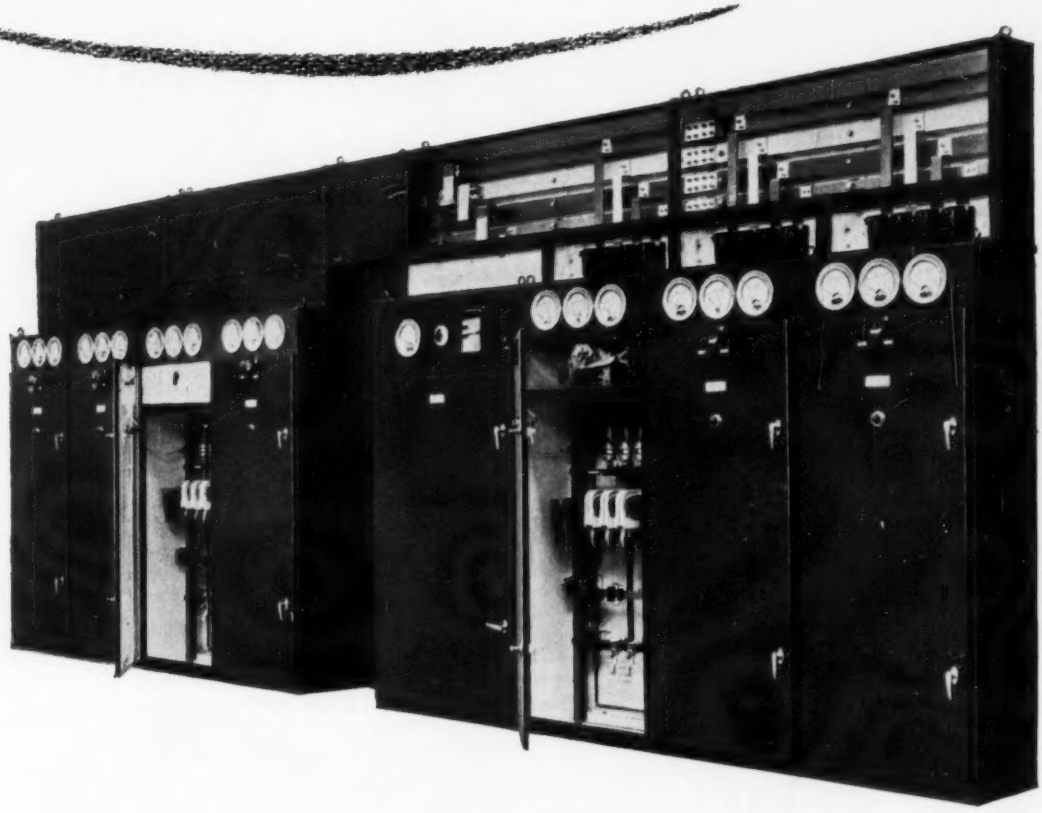

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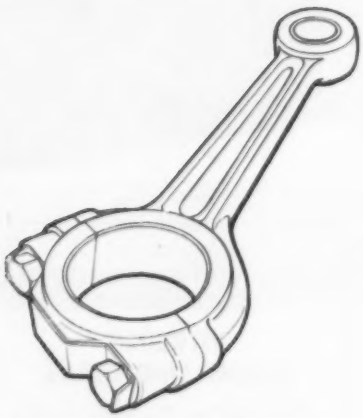

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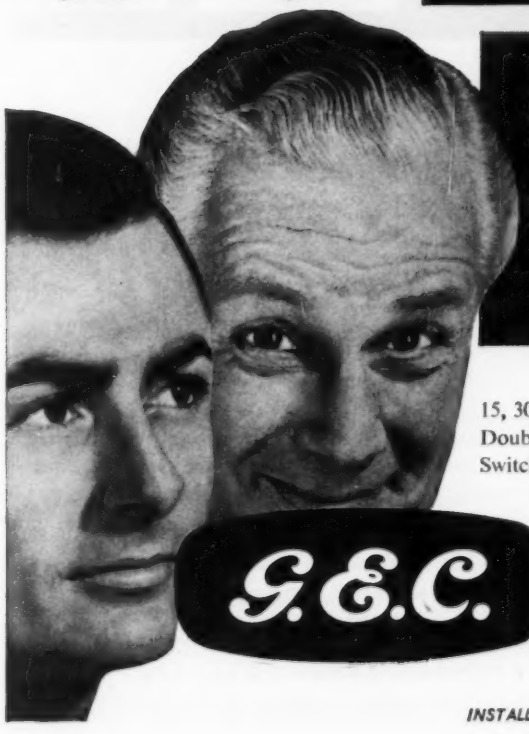

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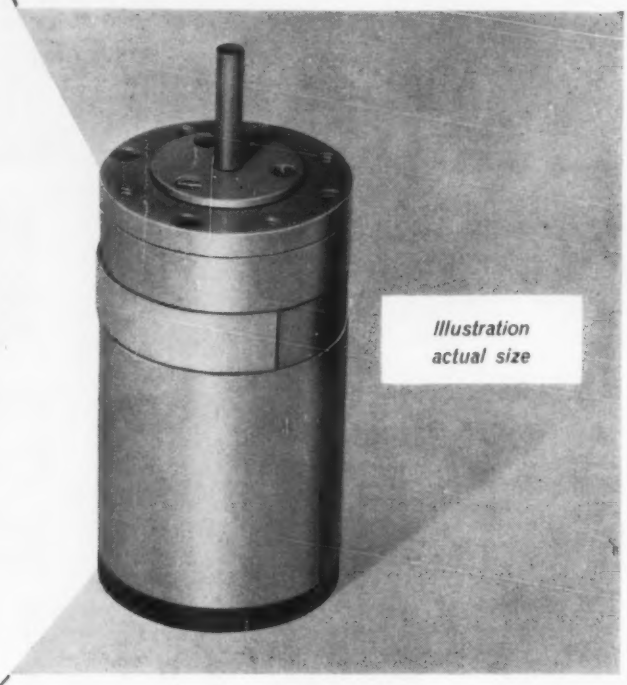


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| Voltage Range: | 8v to 12v DC |
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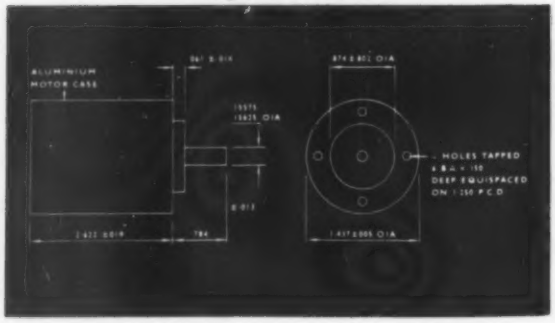
| Rotation: | Anticlockwise viewed from spindle end. |
| Speed and Output: | Max. continuous rating.<br>2440-2500 r.p.m. at 45 grm. cms. torque at 12v DC +0v<br>2390 r.p.m. minimum at 45 grm. cms. torque at 8v DC −0v<br>Speed regulation over governed range at constant voltage 0.75 r.p.m. per grm. cm. torque.<br>Speed regulation over governed range at constant torque 12·5 r.p.m. per volt DC Max.<br>No load ungoverned 12v<br>No load governed 8v<br>Minimum torque at governed speed 15 grm. cm. at 12v DC. |

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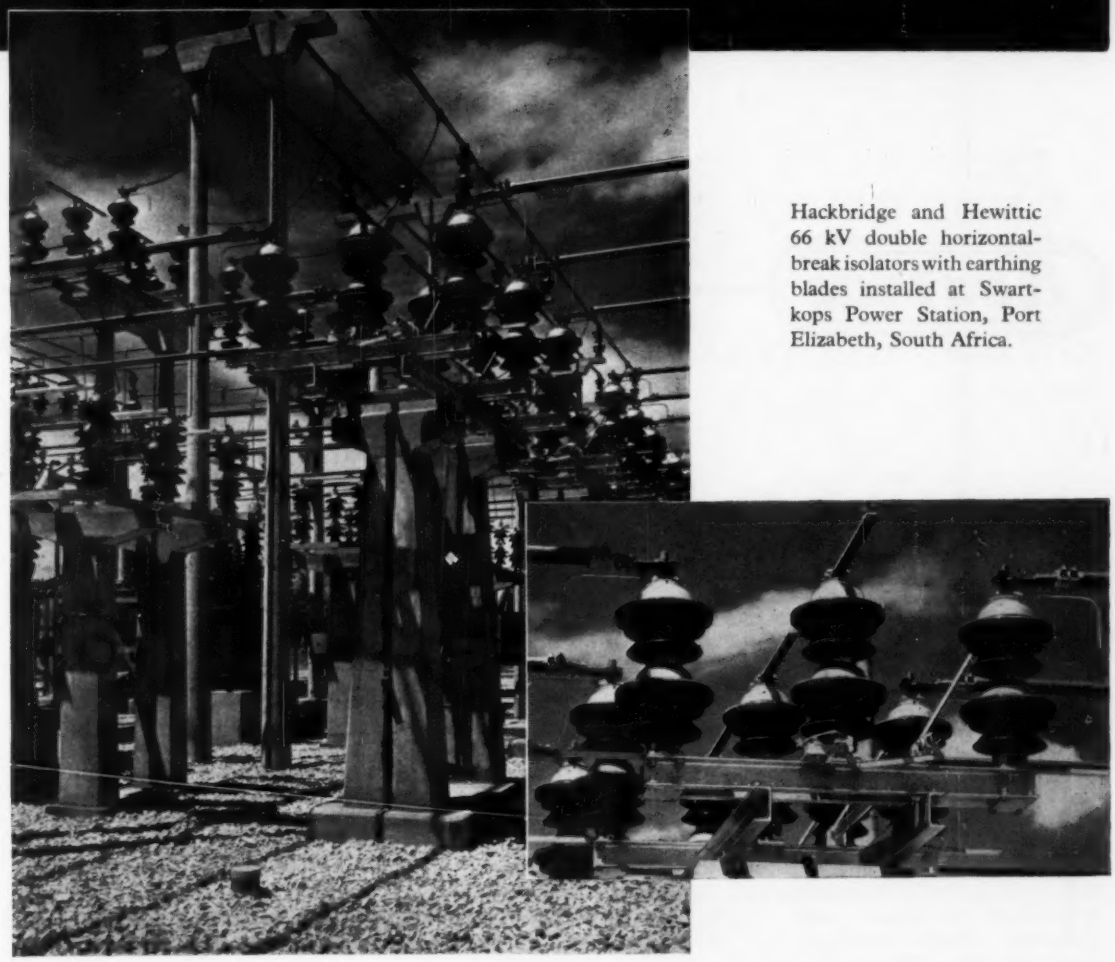

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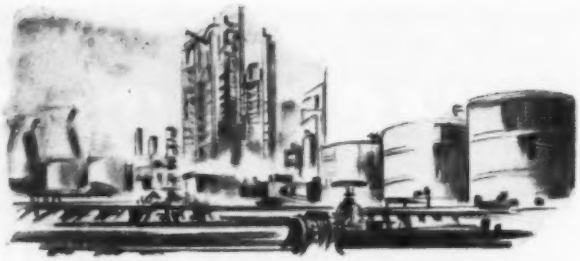

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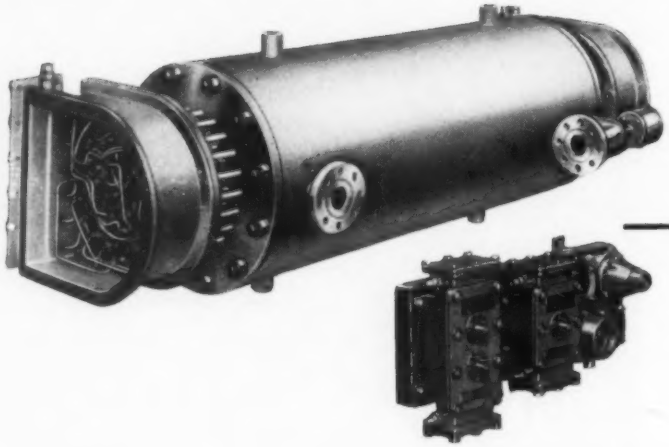

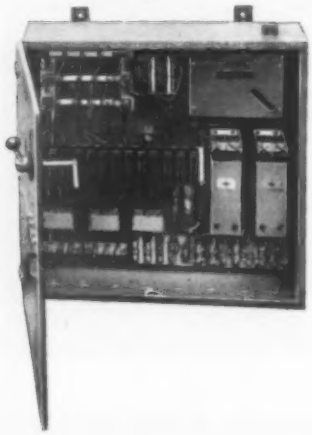

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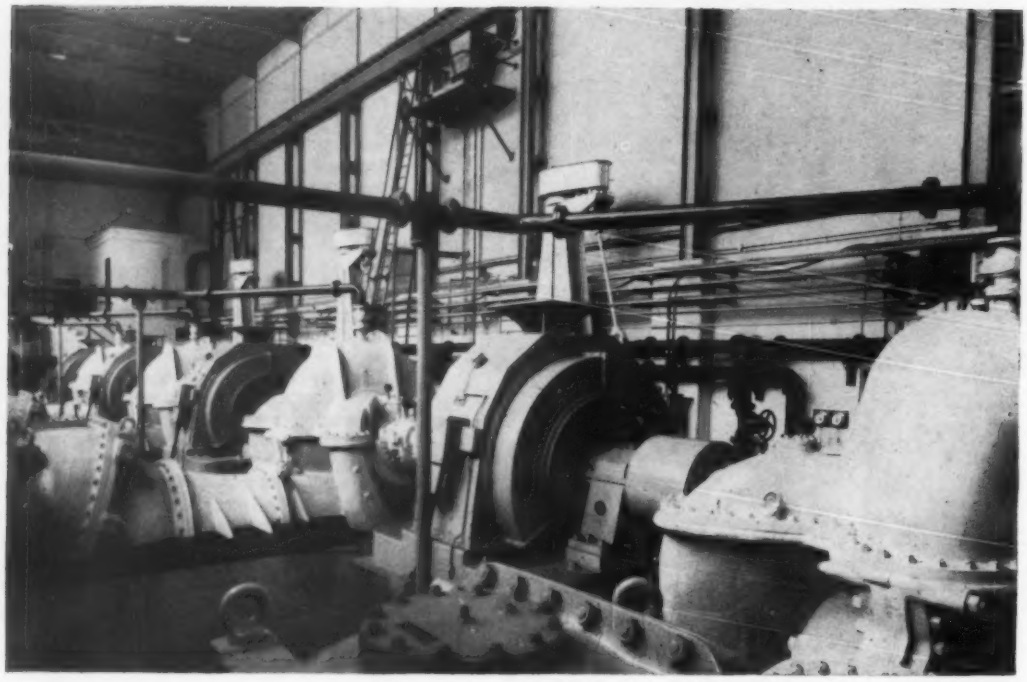

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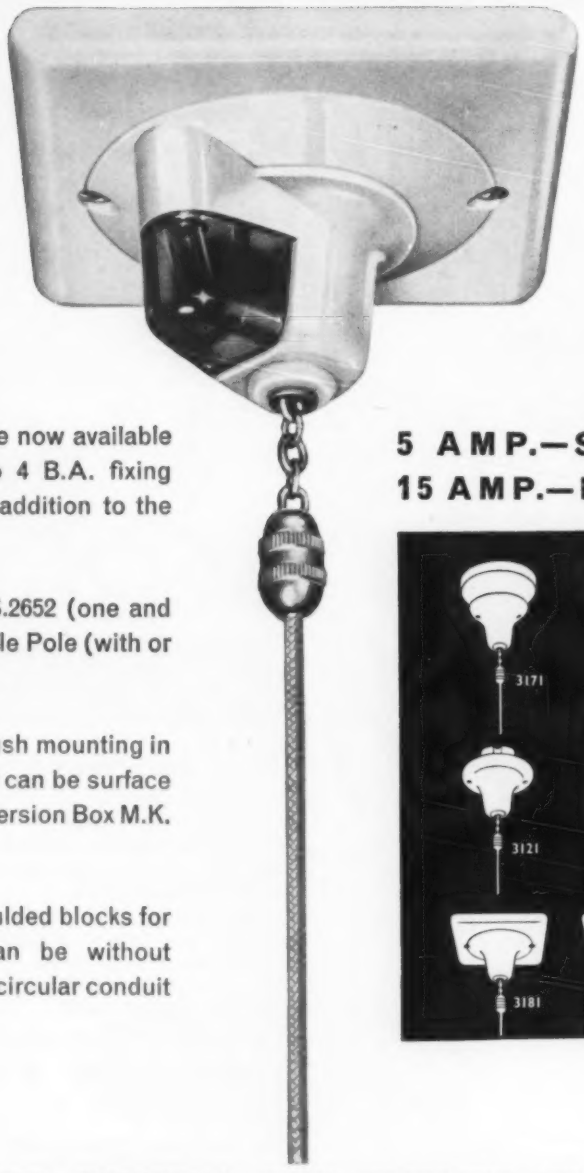

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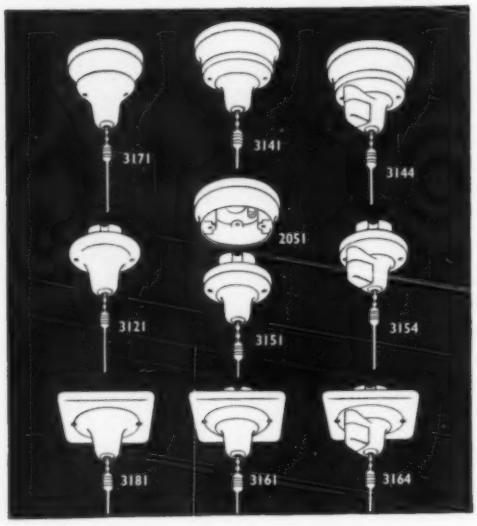


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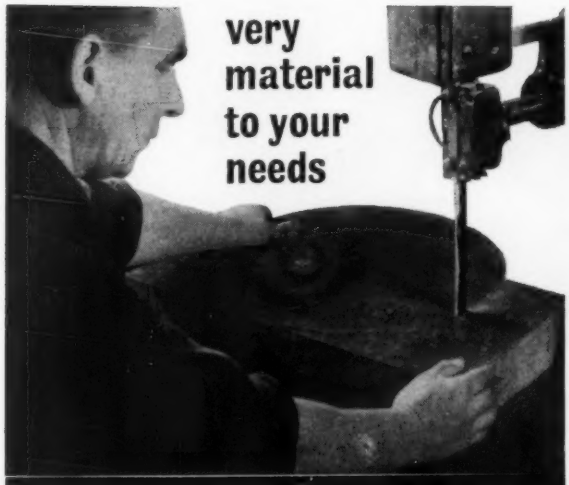

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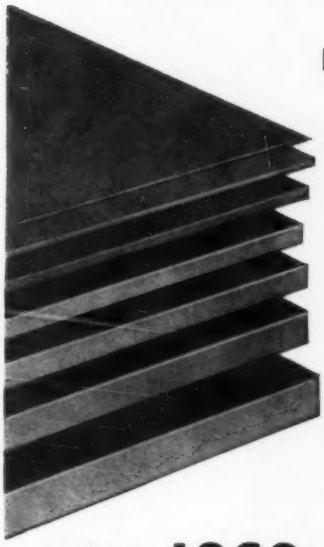

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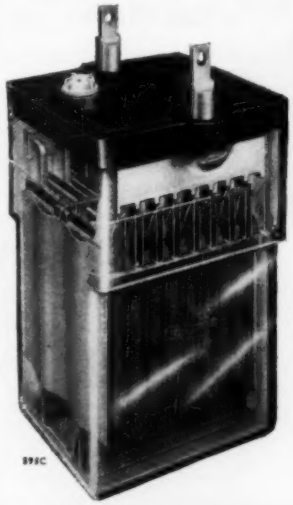

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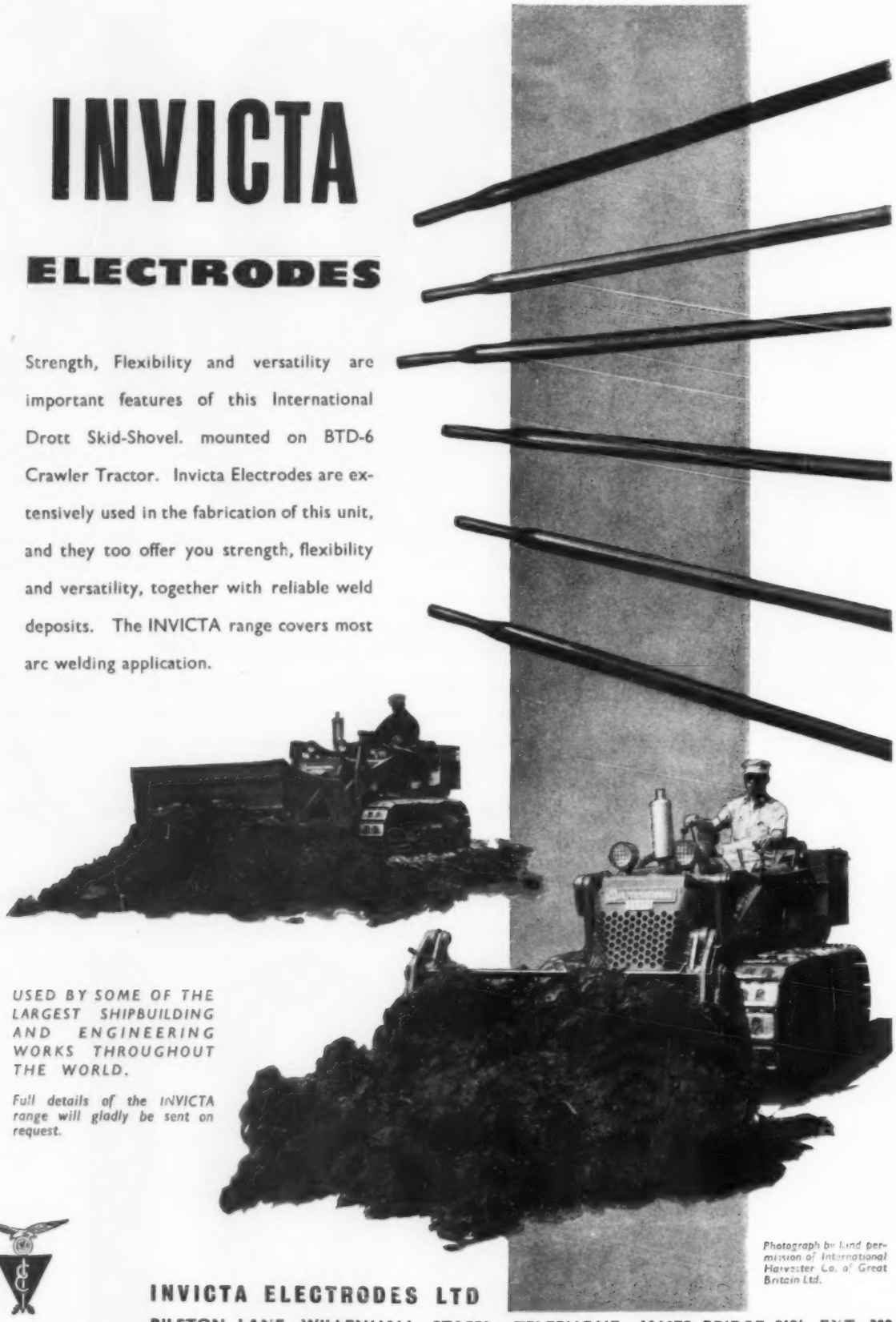

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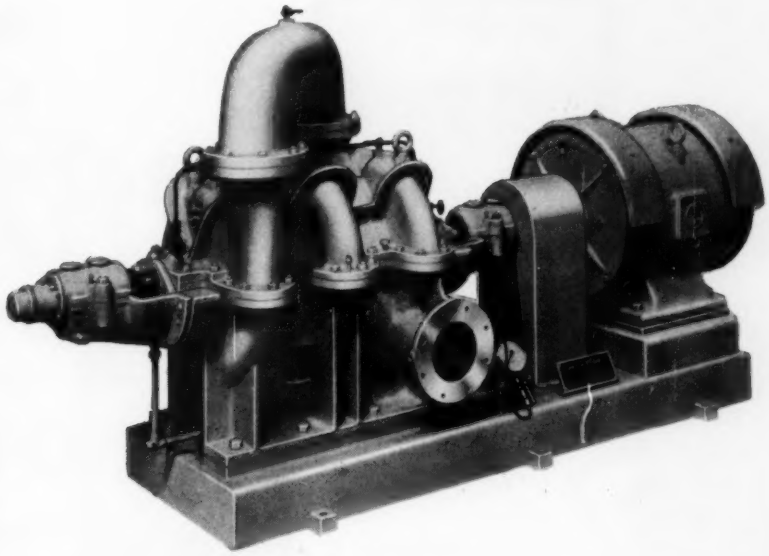

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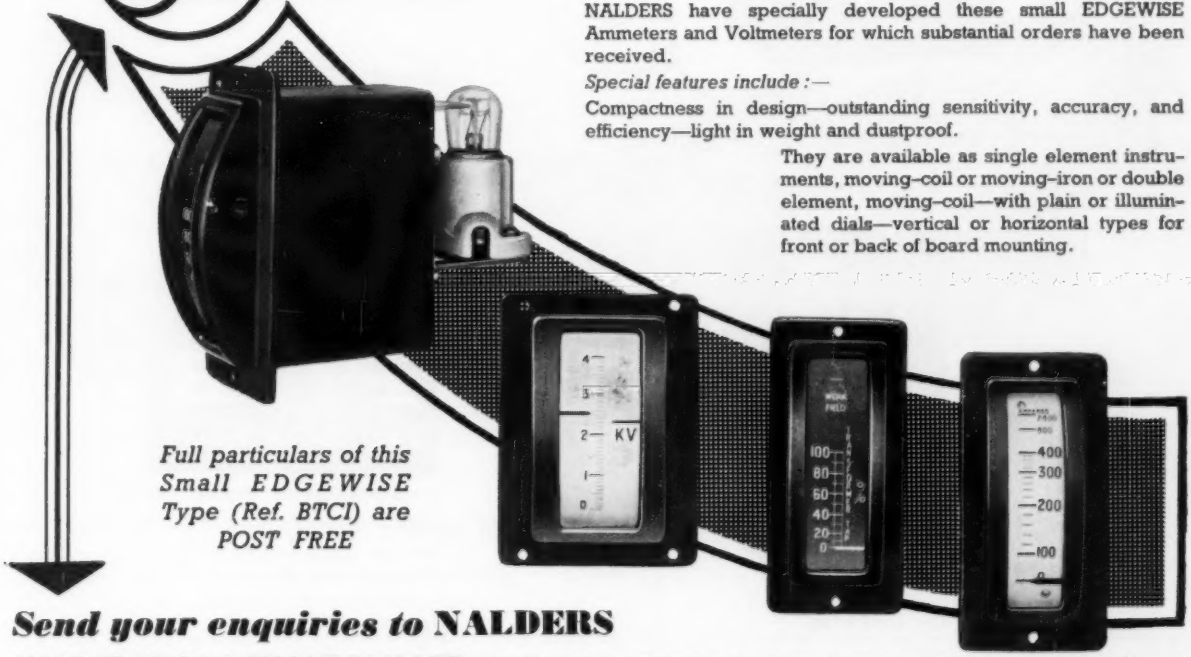


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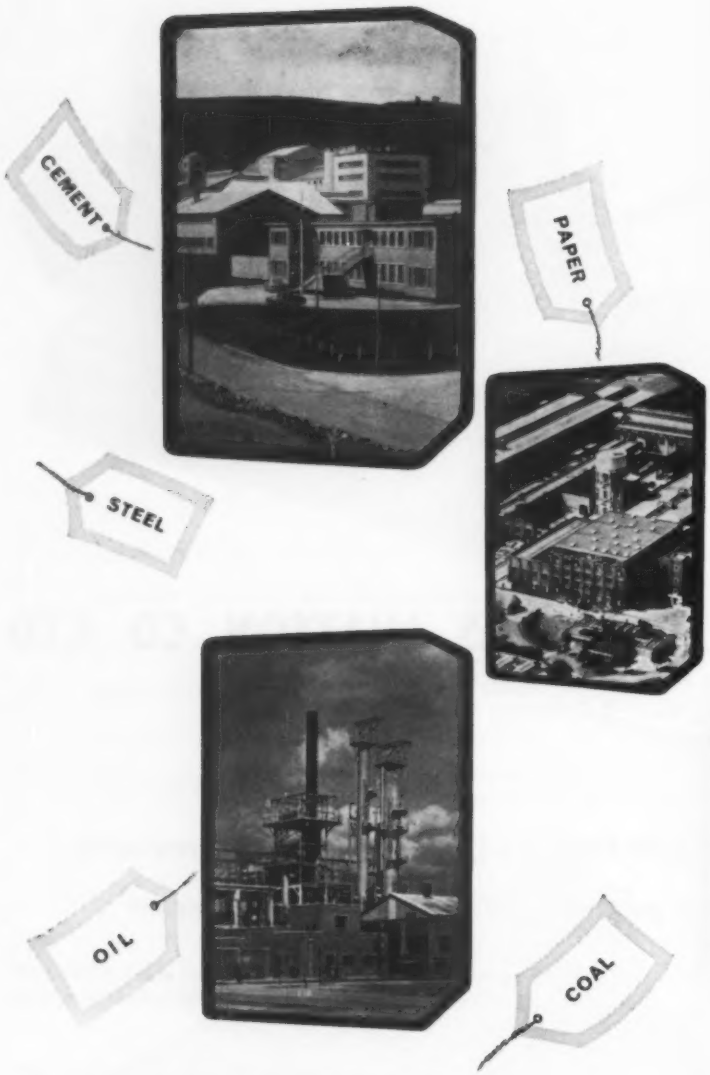


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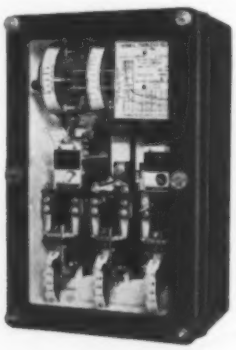

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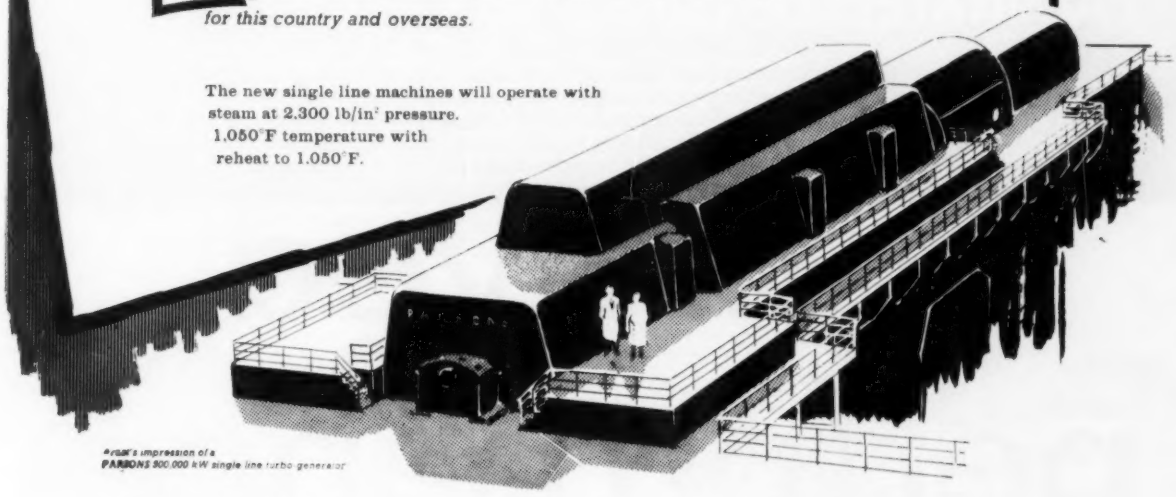

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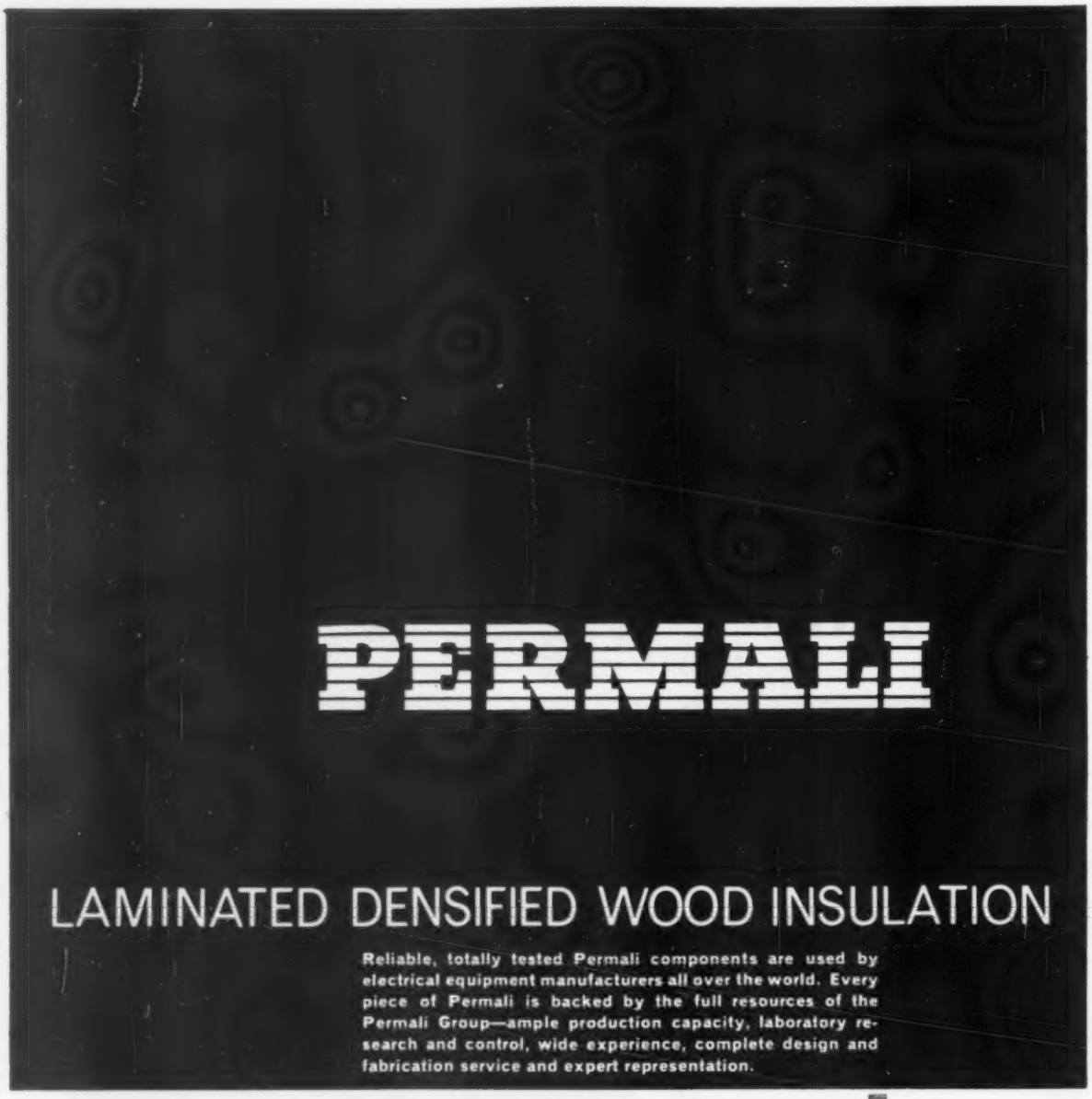
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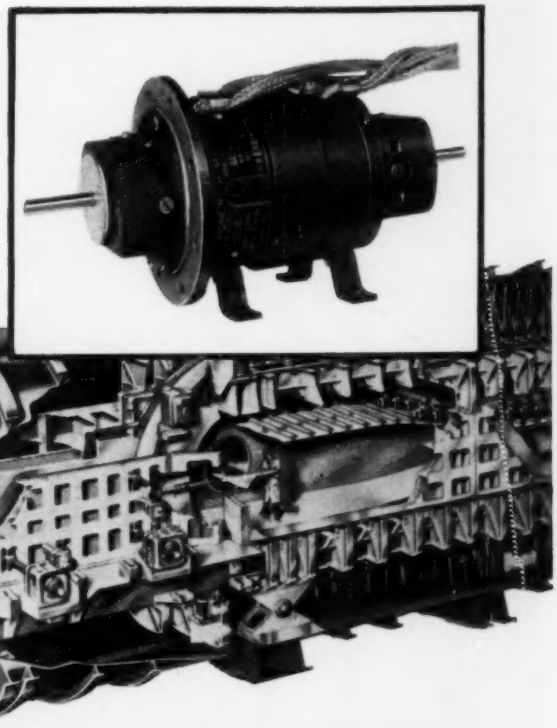

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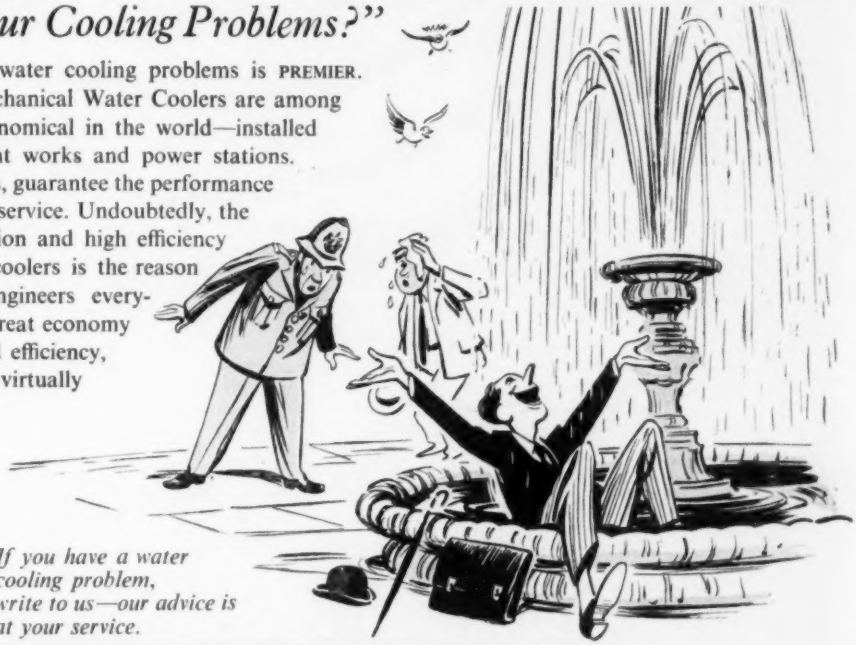

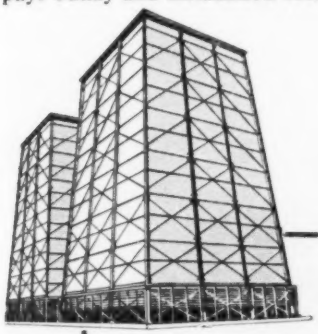

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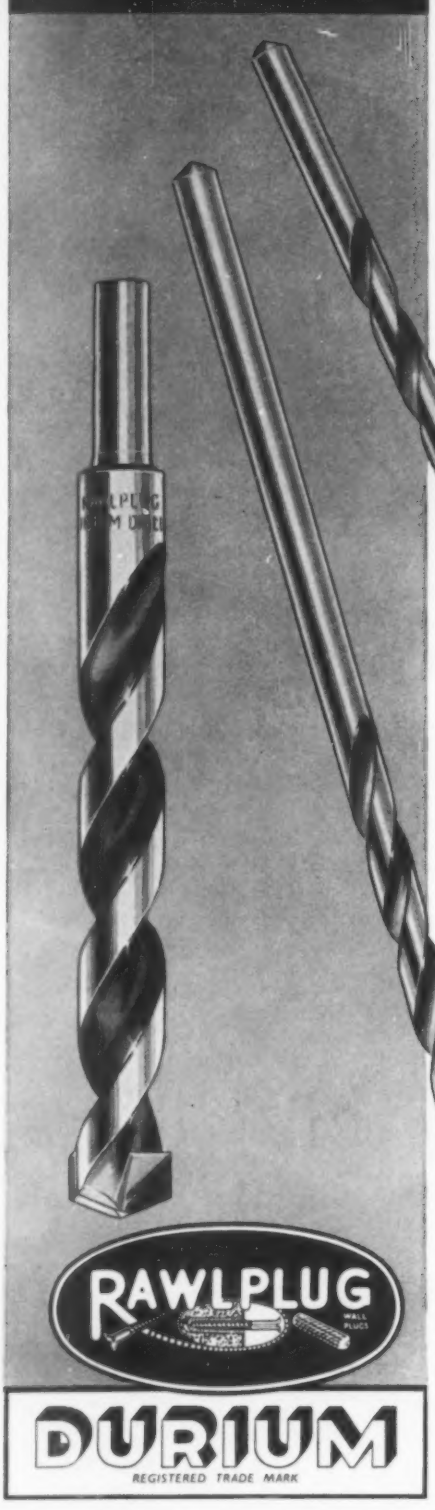


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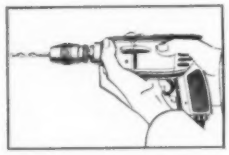

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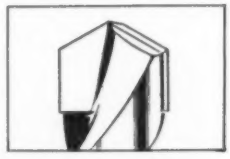

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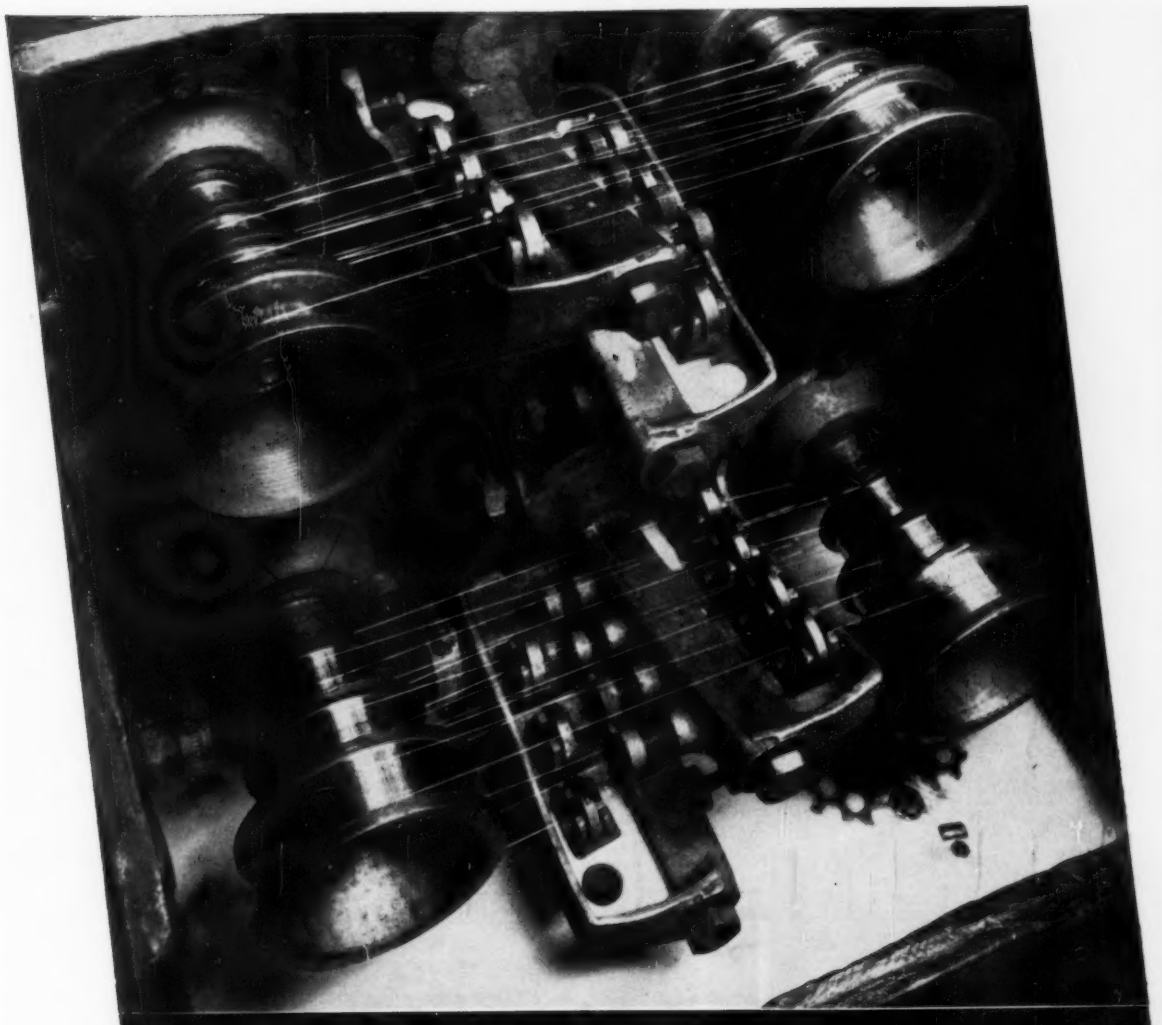

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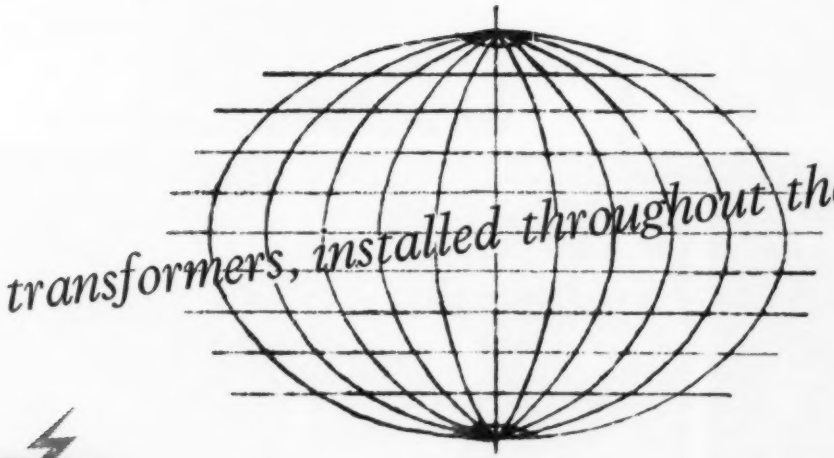


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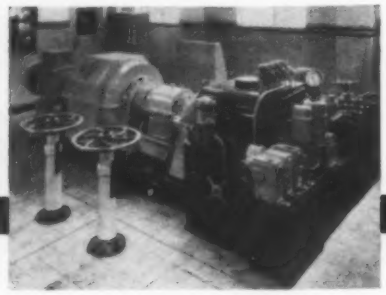
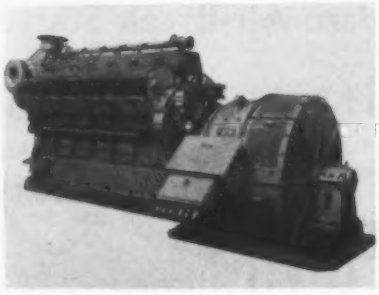
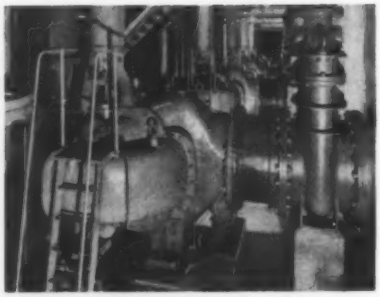


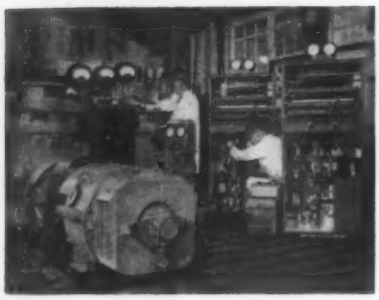
Steam Turbines



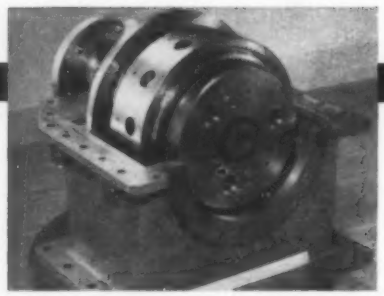
Diesel Engines



Pumps



Electrical Equipment



Gearing

## Comprehensively individual

Whether built as individual machines or as part of comprehensive Allen power and pumping installations, Allen products are tailored to suit specific needs. Specializing in 'specials' is, in fact, an Allen activity as firmly established as the Allen reputation for high-quality engineering.

May we send you details of the equipment we make ?

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1,000 MVA O.C.B.

HYDRAULICALLY ACTUATED O.C.B.
CLOSING MECHANISM.

FULL MAINTENANCE POSSIBLE WITHIN
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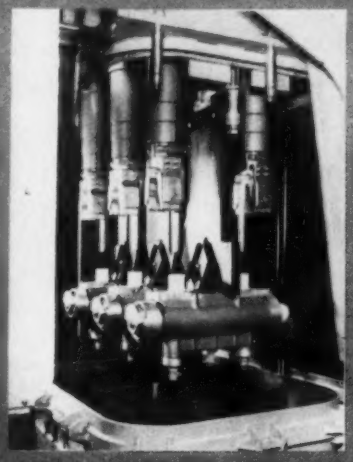

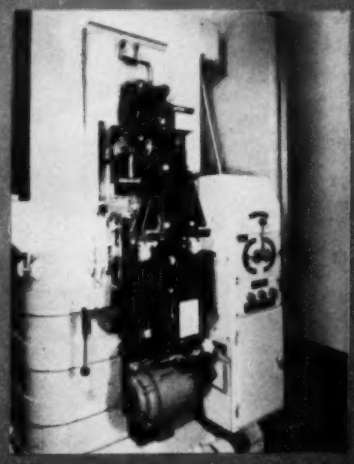

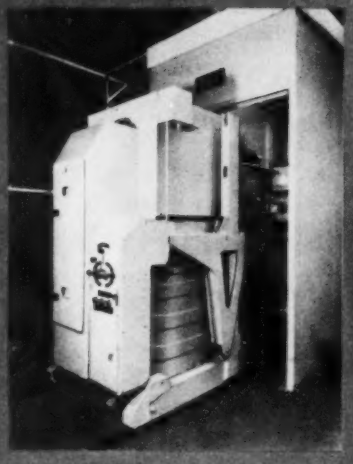

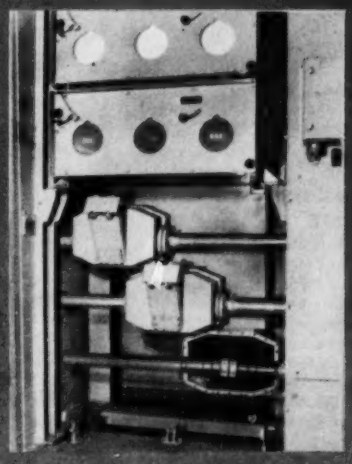

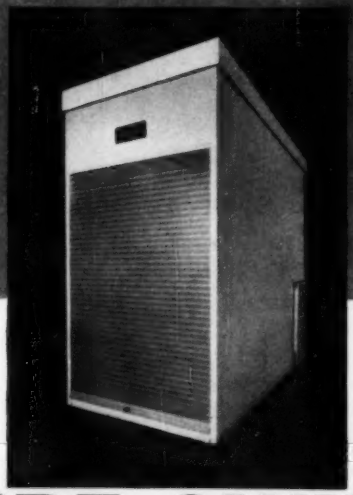

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ELECTRO-HYDRAULICALLY OPERATED.

CONDENSER TYPE BUSBARS WITH
TEE-OFF JUNCTION BOXES.

A COMPACT SELF CONTAINED WEATHERPROOF
UNIT ON 5' 9" CENTRES.

# YORKSHIRE SWITCHGEAR & ENGINEERING CO. LTD.

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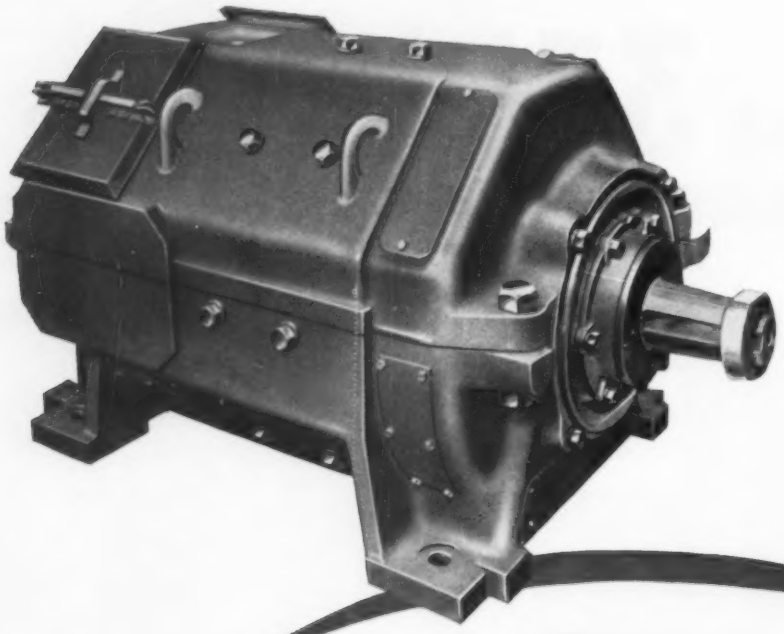

# Over 4,000 good reasons for choosing MDX mill motors

**SOME OF THE MANY FAMOUS USERS OF MDX MOTORS:**

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Brown Bayley Steels Ltd.
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Over 4,000 MDX-type mill motors have gone into service during the last eight years in leading iron- and steel-producing works in Britain and many other parts of the world. They have established a good reputation for efficient and continuous duty. Remarkable reliability and strength, together with low inertia of rotating parts, make MDX motors ideal for driving a wide range of steelworks equipment. They have been specifically designed to withstand arduous service and are unaffected by heavy overloads. Available totally enclosed, up to 200 h.p., self-ventilated, up to 250 h.p.

*Please write for further details to* INDUSTRIAL MACHINES DEPT, TRAFFORD PARK, MANCHESTER 17

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MOTOR & CONTROL GEAR DIVISION RUGBY AND MANCHESTER ENGLAND

A5568

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*Siemens Ediswan 4-way, 4-wire Fuse or Link Disconnecting Box.*

## Just think of the equipment with the AEI name behind it!

Distribution pillars and panels – Underground disconnecting boxes, branch boxes, service boxes and straight-through joints – Indoor and outdoor terminal boxes – Indoor and outdoor service fuses – H.T. and super-tension joints and sealing ends – Overhead service accessories – Rising mains systems – House service fuses and consumers' control units – Jointing materials and accessories of every description.

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*The "Safetymaster" Power Tool made by Wolf Electric Tools Ltd., is an excellent example of modern power tool design. The cutaway section indicates the ingenious application of Beetle DMC material for double insulation.*

Beetle Polyester DMC is used by Wolf Electric Tools Ltd., for *double insulating* their Safetymaster Power Tool. Mouldings in Beetle DMC have excellent anti-track and electrical insulation properties, good heat resistance and high mechanical strength. Compatibility with metals and dimensional stability are really outstanding for thermosetting materials. Beetle DMC is a *fast-curing* compound and can be moulded in conventional compression and transfer presses. Write for technical leaflets.

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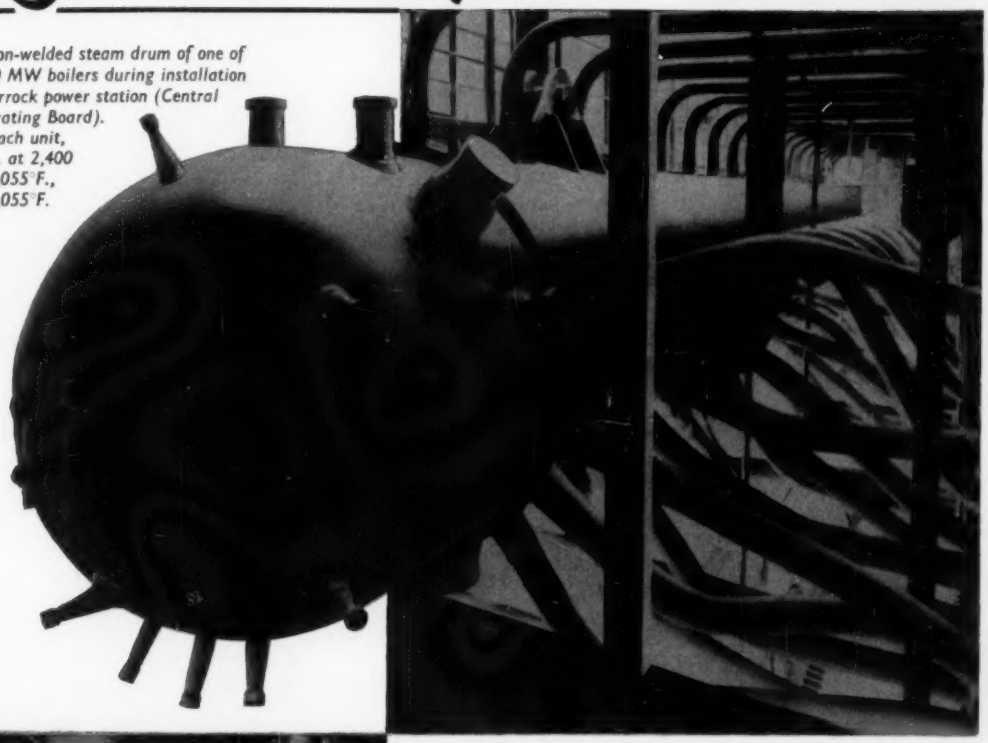
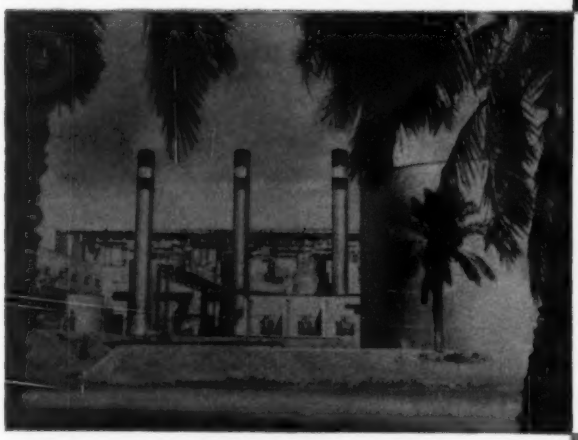
B·I·P

# *Meeting World-wide power demands*

*The 155-ton fusion-welded steam drum of one of two Babcock 200 MW boilers during installation at the West Thurrock power station (Central Electricity Generating Board). Evaporation of each unit, 1,350,000 lb./hr. at 2,400 lb./sq. in. and 1,055°F., with reheat to 1,055°F.*

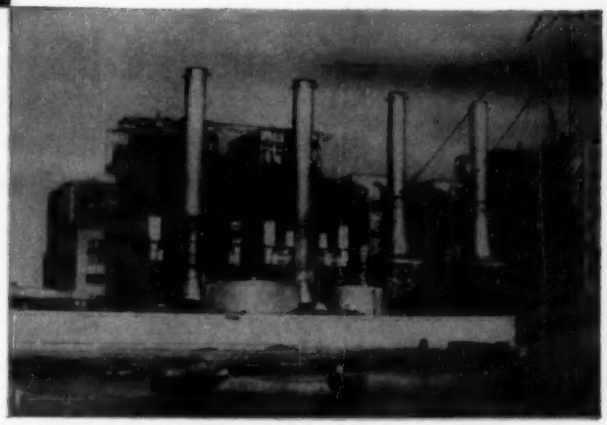




**STEAM** is, by far, the world's most important medium for electrical-power generation and a very high proportion of the world's power stations is equipped with BABCOCK steam-raising plant.
Recent contracts for home and overseas central station boilers include units of 200, 300, and 550 MW capacity, a number to operate on a reheat cycle, and a 375 MW boiler of the "once-through" type to generate steam at super-critical pressure—3650 lb./sq. in. and 1110°F. with reheat to 1055°F.

*(Above) Power station at Basrah, Republic of Iraq, equipped with three 165,000 lb./hr. BABCOCK Type FH Integral-Furnace, oil and natural-gas fired boilers. (Consulting Engineers : Ewbank & Partners).*

*(Right) VENEZUELA. Babcock boilers at the Tacoa power station of La Electricidad de Caracas, including units of 550,000 lb./hr. capacity, fired by oil and natural gas. (Consulting Engineers : Sofina).*



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**STEAM-RAISING PLANT**

**BABCOCK & WILCOX LTD., BABCOCK HOUSE, 209 EUSTON ROAD, LONDON, N.W.1**

# *Steelwork for Power Stations*

Throughout the country steel-framed Power Station structures indicate the close association of ARROL of GLASGOW with Britain's electrical power development. Battersea and others in the London area, Castle Donington in Leicestershire and Braehead at Glasgow comprise a long series now being further extended by the erection of the steel framework of Belvedere Power Station—another of the London Group.

*All types of Steel Framed Buildings; Fixed and Opening Bridges; Cranes and Mechanical Engineering work; Dock Gates; Sliding and Floating Caissons; Compressed Air Locks; Hydraulic Machinery; Pipe Lines, Surge Tanks, Sluices and other equipment for Hydro-Electric Projects.*

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### EXTRUDED AND DRAWN SECTIONS

**All shapes for electrical and other purposes**

BOLTON'S PRODUCTS include copper and copper-base alloys in the form of wire and strand, bar and rod, sheet, strip and foil, busbars, commutator segments and tubes.

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## SOME BEAMA PUBLICATIONS

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5s. net.

**Recommendations for the Insulation Level of Power Transformers**
(Publication No. 156)
5s. net.

**Problems of Power Transmission at Voltages above 225 kV**
by François Cahen, Directeur-Adjoint des Etudes et Recherches à l'Electricité de France.
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5s. net.

The British Electrical & Allied Manufacturers' Association
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Publications Department: 36 Kingsway, London, W.C.2

# It's aluminium

Sheathed in *seamless* extruded aluminium, this cable is lightweight yet strong. It needs no armouring, thus allowing simple cable design. With a high resistance to vibration fatigue, it can be used with complete safety, alongside railways etc.

# It's flexible

Corrugation results in greater flexibility, permitting the same bending radius as a lead sheathed cable. Not only are handling qualities improved but corrugation reduces the required thickness of the sheath *by one half*.

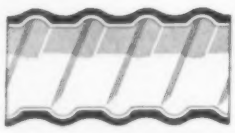
# It's a money saver

Initial costs are therefore lower than conventional type cables of similar performance. Lightness and flexibility simplify transportation and installation.

*Further information is available on request.*

# It's the BICC C.S.A. cable

CORRUGATED
SEAMLESS
ALUMINIUM



**PROTECTIVE SERVING**

Anti-corrosion protection is provided by an extruded P.V.C. covering which fits tightly over the whole sheath surface. *See section view.*

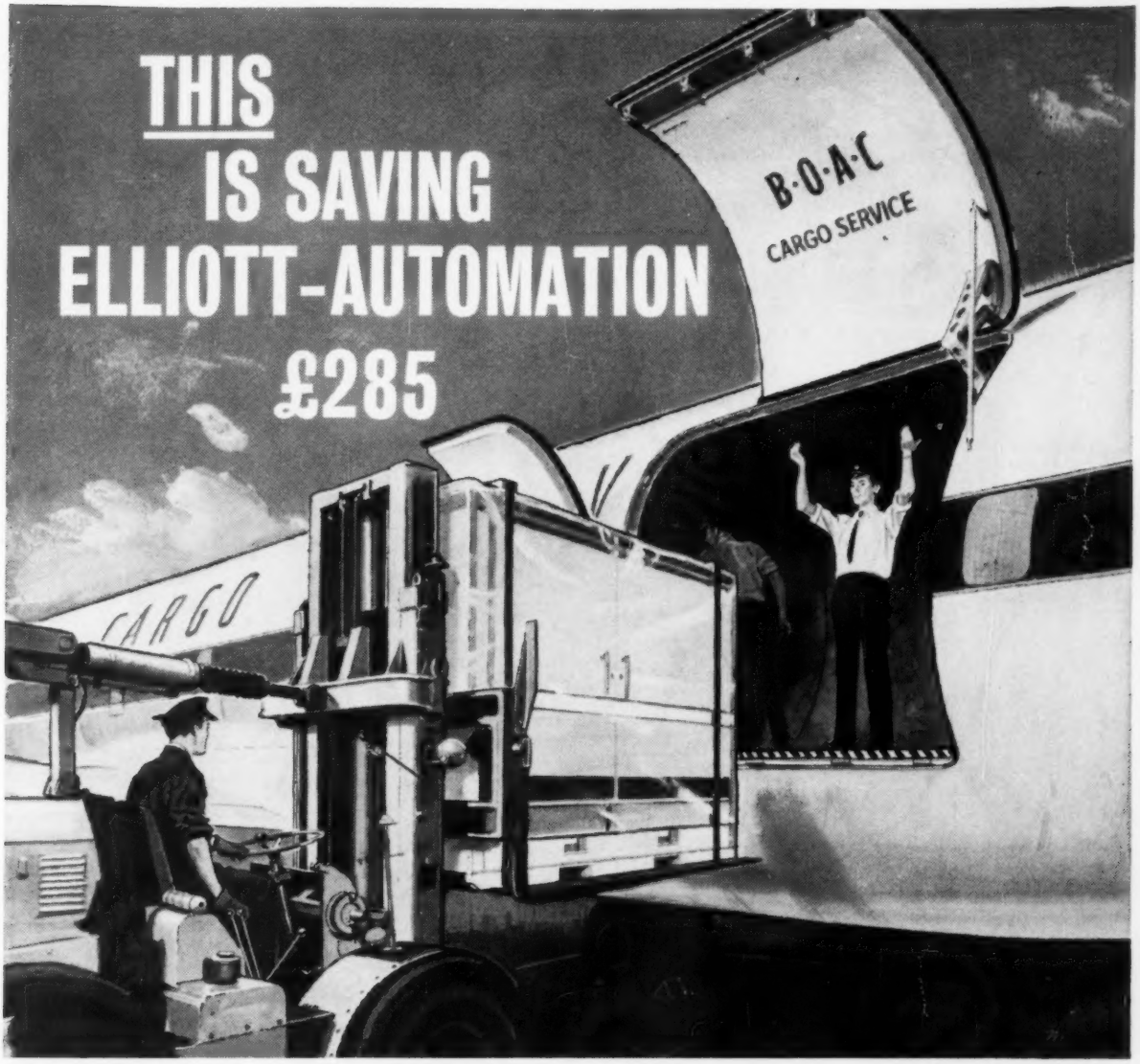
**INSTALLATION**

Conventional installation procedure is followed. Jointing techniques are the same as for normal smooth aluminium-sheathed cables.

**CABLE TYPES**

C.S.A. sheathing is available with BICC Mass - Impregnated Non - Draining (M.I.N.D.) Cables up to 33kV and for Oil-Filled Cables.

BRITISH INSULATED CALLENDER'S CABLES LIMITED 21 BLOOMSBURY STREET LONDON W C 1



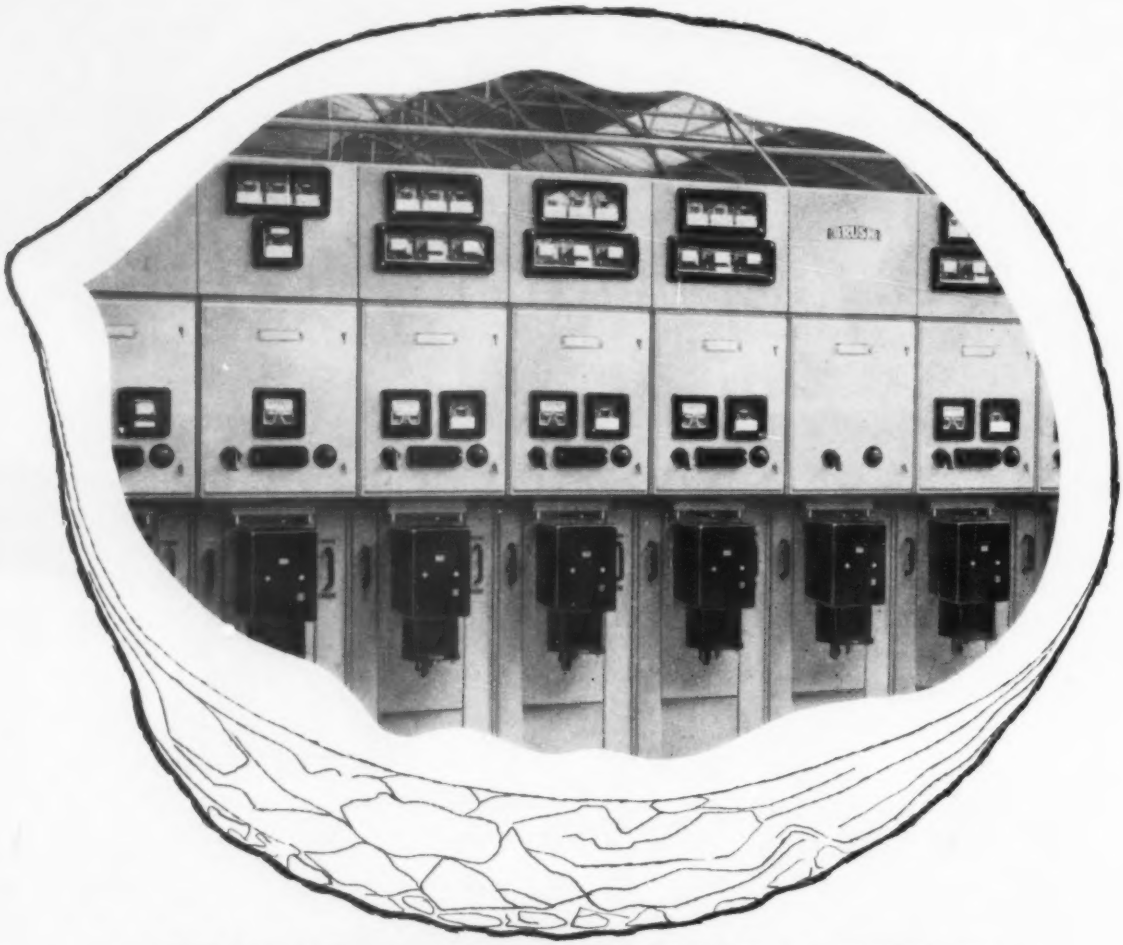

By using BOAC air freight, costs of shipping the National-Elliott 803 Electronic Computer from factory to Chicago, U.S.A. were cut from £735 to £450. Elliott-Automation's saving: £285 over comparable surface transport costs!

BOAC's handling record makes them a natural choice as carriers for *any* company whose products require extreme care in transit. Delivery too, is no problem. To North America alone, BOAC offers some 40 scheduled cargo-carrying services a week!

**BOAC's World-Wide Export Advisory Service offers you informed guidance on marketing and distribution developments in over 150 trade centres world-wide. Phone your nearest BOAC office.**

**B·O·A·C** helps speed the export drive

BRITISH OVERSEAS AIRWAYS CORPORATION WITH ASSOCIATE AIRLINES



# HOW COMPACT CAN YOU GET ?

*Switchboards with piecemeal extensions are a thing of the past. This Metalclad Switchgear by Brush not only presents a uniform appearance — it saves space too. Standardised additions can be easily installed — every one as neat as the first.*

Brush Switchgear offers: *Versatility. Compactness at high MVA Ratings. Easily accomplished uprating to higher MVA levels.*

Brush Metalclad Switchgear for Supply Industry and General Industry.

**3.3. kV** 75 MVA 150 MVA · **6.6. kV** 150 MVA 250 MVA 350 MVA
**11. kV** 150 MVA 250 MVA 350 MVA 500 MVA

*For all the above ratings the Brush range can be supplied in 400, 800 and 1,200 ampere units in 2' panel widths and 1,600 ampere units in 2' 6" panel widths. Can be supplied with air-insulated or compound-filled bus bar chambers for single or double bus bar arrangements. All ratings certified by the Association of Short Circuit Testing Authorities to BS 116/1952 and relevant ASTA rules.*

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*A member of the Hawker Siddeley Group.*

# HYDRO-ELECTRIC GENERATORS

Over 50 years ago Bruce Peebles engineered the Snowdon Hydro-Electric Scheme in North Wales —the first large project for public supply in Great Britain.

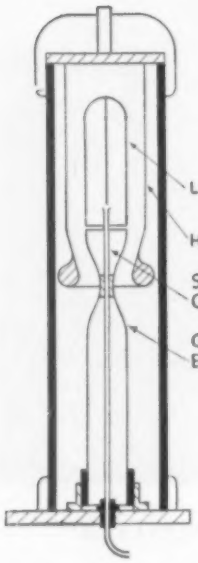
The pioneering spirit which carried the Company to success in the early days is still dominant and is revealed to-day in the many contracts undertaken for large hydro-electric plant for many schemes at home and abroad.

BRUCE PEEBLES EDINBURGH

Partially erected 18 MW vertical generator for the Orrin power station of the North of Scotland Hydro-Electric Board.

**BRUCE PEEBLES & CO. LIMITED,** EDINBURGH, SCOTLAND

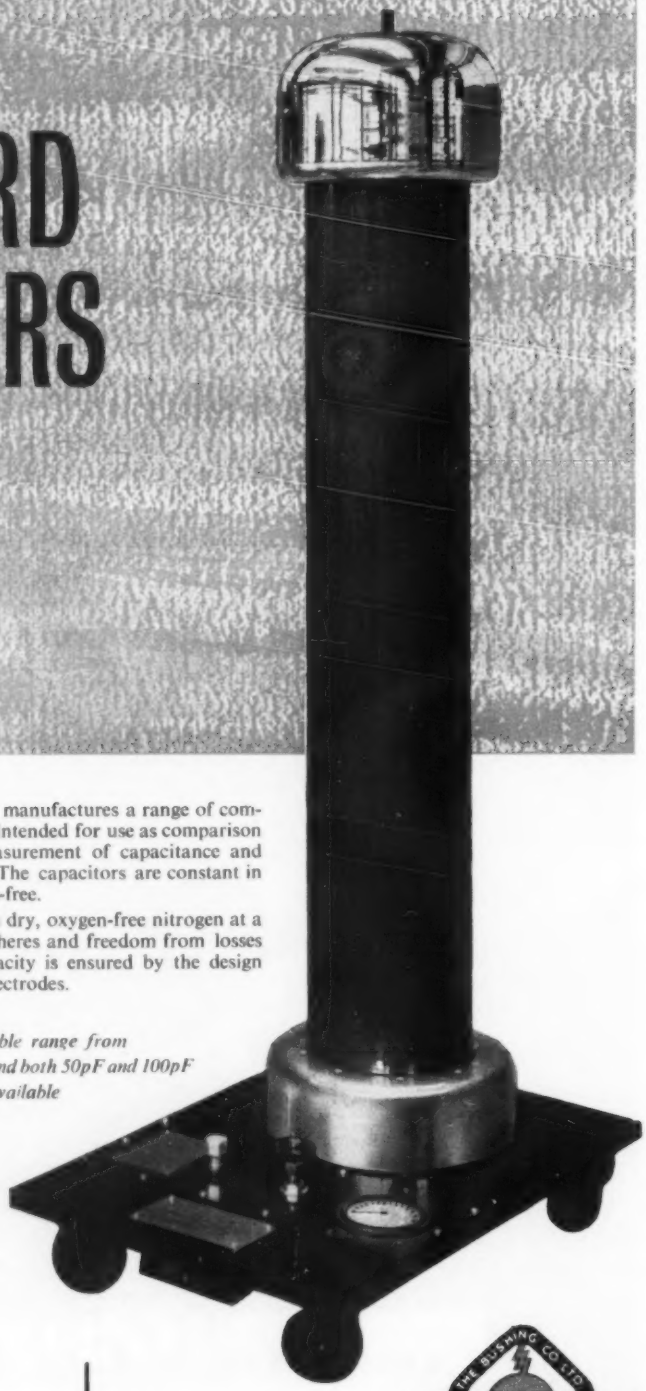
# STANDARD CAPACITORS




The Bushing Co. Ltd. manufactures a range of compressed gas capacitors intended for use as comparison standards for the measurement of capacitance and dielectric loss factor. The capacitors are constant in value and virtually loss-free.

The gaseous insulant is dry, oxygen-free nitrogen at a pressure of 10 atmospheres and freedom from losses and invariance of capacity is ensured by the design and screening of the electrodes.

*The sizes available range from 50kV to 500kV and both 50pF and 100pF capacitors are available in each size.*



**THE BUSHING COMPANY LTD.**
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TEXOLEX
BS

# Can the ILO Insulation Oil Service help you?

By using our regular sampling plan we can tell you if your transformer oil—

- ✳ **is fit for continued service**
- ✳ **should be treated on site to restore its physical condition**
- ✳ **should be works reconditioned to restore its chemical and physical properties**
- ✳ **is unfit for further service**

## OIL SUITABLE FOR CONTINUED SERVICE

Oil in this category should be tested every eighteen months or two years.

## TREATMENT ON SITE

Where customers have no filtration equipment or their filters are inadequate, our Mobile Filter Unit is for hire *on site*. It can handle upwards of 1,000 gallons an hour. For treatment of moisture in the transformer windings we have introduced our ILOVAC unit. It gives the same standard of oil conditioning *on site* as was previously available only at manufacturers' works. The ILOVAC is capable of removing, almost completely, both dissolved water and air from transformer oil.

## RECONDITIONING OIL AT WORKS

When the state of oil is so bad that treatment on site would be ineffective, our works reconditioning service is available. By this service only, can oxidised and acidic oil be restored to a standard suitable for future use.

## OIL UNFIT FOR FURTHER SERVICE

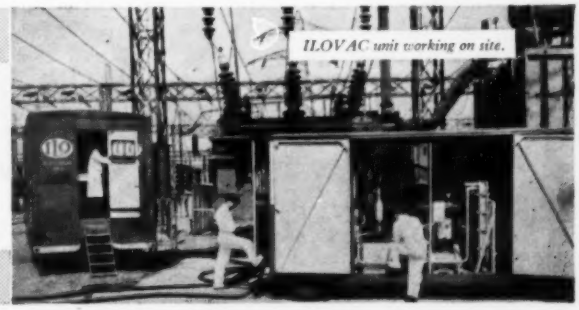
When oil has deteriorated to such an extent as to be unfit for treatment, the transformer should be washed down thoroughly with clean oil to minimise contamination of a fresh charge. We can arrange for the disposal of the waste oil if you have any difficulty.

Castrol ELECTRICAL OILS

**CASTROL INDUSTRIAL LIMITED**

**Electrical Division, Castrol House, Marylebone Road, London, N.W.1**

*Telephone: HUNter 4455*



*ILOVAC unit working on site.*

# *Two heads are better than one*

If you have a problem on your mind involving the movement of air or other gases you can't do better than to get in touch with 'Sirocco'.

Over the past 75 years we've accumulated a vast amount of experience in this field. You'll find 'Sirocco' fans and ancillary equipment in thousands of British factories, in many British coal mines, in most British power stations, and in industrial establishments throughout the world. Whether it's heating and ventilating, air conditioning, fume or vapour removal, dust collection, or the pneumatic conveying of bulk material, there's a "Sirocco" answer for the asking.

We'll be glad to send a 'Sirocco' trained engineer from our nearest branch to survey the situation. Can we get our heads together on *your* problem?

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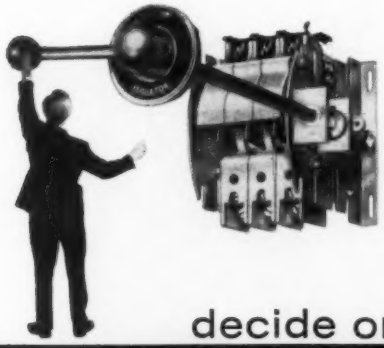


# We don't supply them THIS size . . . . but!

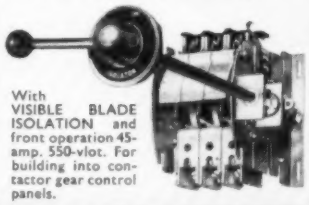
All the accessories shown below are of a convenient and suitable size for your use

decide on

# DONOVAN

## CONTROL ACCESSORIES

**Load-breaking Isolating Switches Type K10**

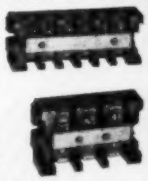


With VISIBLE BLADE ISOLATION and front operation 45-amp. 550-vlot. For building into contactor gear control panels.

**Limit Switches (Type C32L 810/1)**

Plunger pattern with roller on end. Roller can be moved through 90 degrees and the switch can be altered from N.O. to N.C. on site. Box: 2½" wide × 2¾" high. Plunger: 1¼" C.S.A. approved.

**Terminal Blocks (Type J96)**



Clamp-type terminals. White marker strip, generous clearances between phases and to earth. 15 & 30-amp 660-volt. 3 and 4-way. C.S.A. approved.

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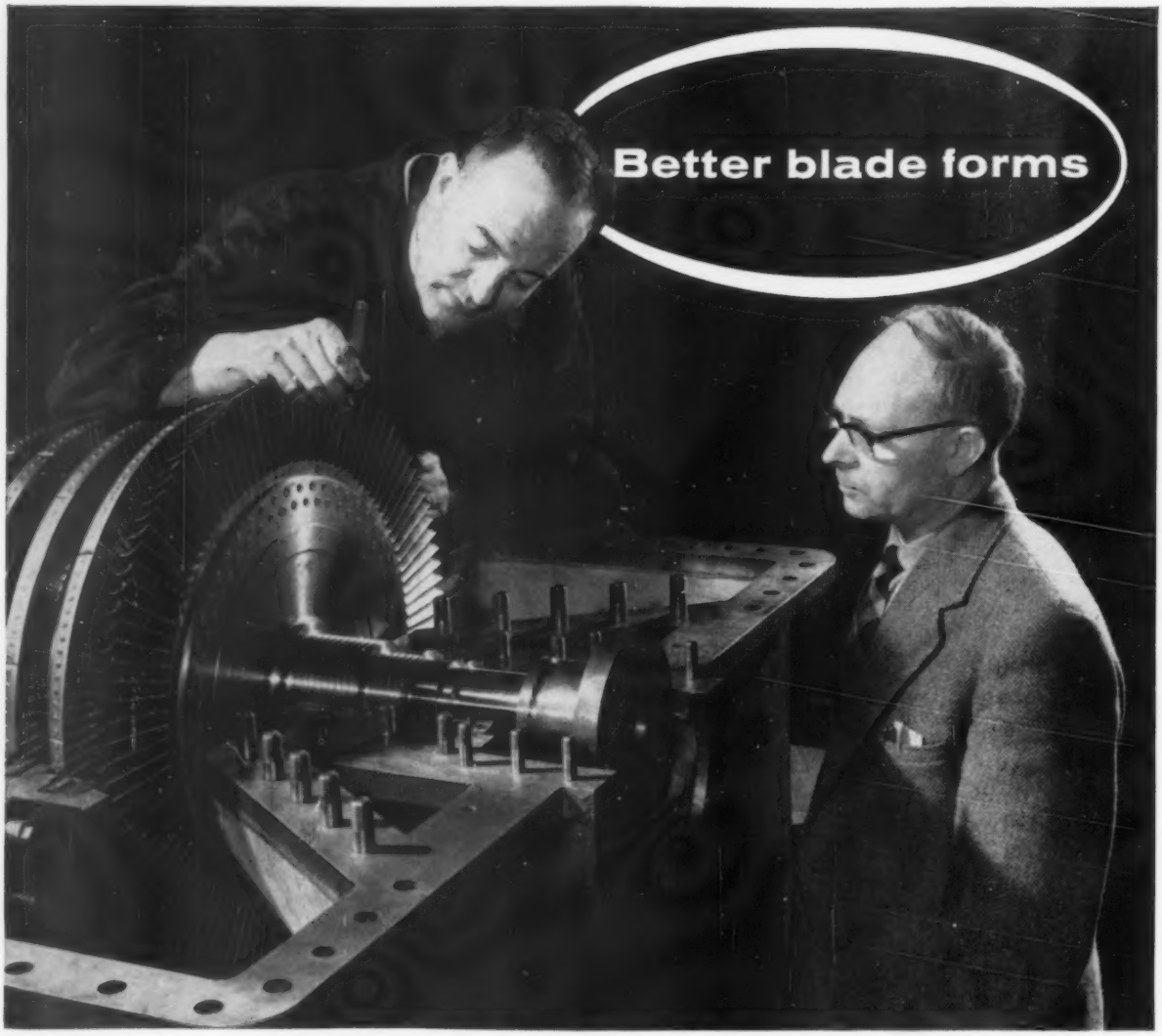


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